Appendix B
Evaluation of Fishing Activities That May Adversely Affect Essential Fish Habitat

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National Marine Fisheries Service

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CONTENTS

FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

AFSC	Alaska Fisheries Science Center
AI	Aleutian Islands
BS	Bering Sea
BSAI	Bering Sea and Aleutian Islands
Council	North Pacific Fishery Management Council
EFH	essential fish habitat
FMP	Fishery Management Plan
GIS	geographical information systems
GOA	Gulf of Alaska
km	kilometer
LEI	Long-term Effect Index
m	meter
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MSST	Minimum Stock Size Threshold
MT	minimal or temporary effect
nm	nautical miles
NMFS	National Marine Fisheries Service
ppm	parts per million
ppt	parts per thousand
QS	Quality Scores

B.1 Overview

This appendix addresses the requirement in EFH regulations (50 CFR 610.815(a)(2)(I)) that each FMP must contain an evaluation of the potential adverse effects of all regulated fishing activities on EFH. This evaluation must 1) describe each fishing activity, 2) review and discuss all available relevant information, and 3) provide conclusions regarding whether and how each fishing activity adversely affects EFH. Relevant information includes information regarding the intensity, extent, and frequency of any adverse effect on EFH; the type of habitat within EFH that may be affected adversely; and the habitat functions that may be disturbed.

In addition, the evaluation should 1) consider the cumulative effects of multiple fishing activities on EFH, 2) list any past management actions that minimize potential adverse effects on EFH and describe the benefits of those actions to EFH, 3) give special attention to adverse effects on habitat areas of particular concern and identify any EFH that is particularly vulnerable to fishing activities for possible designation as habitat areas of particular concern, 4) consider the establishment of research closure areas or other measures to evaluate the impacts of fishing activities on EFH, 5) and use the best scientific information available, as well as other appropriate information sources.

This evaluation assesses whether a fishing activity is adversely affecting EFH in a manner that is more than minimal and not temporary in nature (50 CFR 610.815(a)(2)(ii)). This standard determines whether Councils are required to act to prevent, mitigate, or minimize any adverse effects from fishing, to the extent practicable. Therefore, this evaluation is structured to address the minimal and temporary standards.

Much of the material required for this evaluation is located in other sections of this document. These areas include the following:

- Descriptions of fishing activities (including gear, intensity, extent and frequency of effort) - Sections 3.4.1 and 3.4.2.
- Effects of fishing activities on fish habitat - Section 3.4.3
- Past management actions that minimize potential adverse effects on EFH - Sections 2.2.2 and 4.3.2
- Habitat requirements of managed species - Sections 3.2.1, 3.2.2, and Appendices D and F.
- Features of the habitat - Sections 3.1, 3.2.4 and 3.3.
- Habitat areas of particular concern - 2.2.2.7, 2.2.2.8, 2.3.2, and 4.2

Information from these sections is included by reference to avoid duplication. Specific information from these sections will be repeated in this appendix where it is applicable to the remainder of the evaluation.

Relevant rules and definitions from regulations and corresponding determinations

As defined in the regulations, “Essential fish habitat means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.”

For the purpose of interpreting the definition of essential fish habitat, “waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; “substrate” includes sediment, hard bottom, structures underlying the waters, and associated biological communities; “necessary” means the habitat required to support a sustainable fishery and the managed species’ contribution to a healthy ecosystem; and “spawning, breeding, feeding, or growth to maturity” covers a species’ full life cycle (50 CFR 600.10).

This definition differentiates essential fish habitat from all other fish habitat based on the extent that the habitat's support of a managed species affects that species' a) ability to support a sustainable fishery and b) ability to fulfill its role in a healthy ecosystem. While habitat functions support individual fish and are affected by fishing at local scales, the support of fisheries and ecosystem roles are accumulated across entire fish populations and ecosystems. Therefore, the appropriate scale for assessing the consequences of the effects of fishing on EFH is that of populations and ecosystems. The importance of habitat properties at specific sites depends on the role of local habitat functions in the full support of each managed species by all habitats. Negative effects to habitat function at specific sites may constitute adverse effects to EFH, but the relevant question is whether the effects are localized and are not consequential to a stock of a managed species, or conversely, whether site specific effects cumulatively have adverse consequences to a stock of a managed species. In other words, do such effects impair the ability of a managed species to support a sustainable fishery or its role in a healthy ecosystem? This does not mean that site-specific effects are not assessed, rather that their cumulative consequences must be considered to evaluate effects on the EFH of each species.

The regulatory language guiding the assessment of effects in this evaluation states that "Each FMP must minimize to the extent practicable adverse effects from fishing on EFH, including EFH designated under other Federal FMPs. Councils must act to prevent, mitigate, or minimize any adverse effects from fishing, to the extent practicable, if there is evidence that a fishing activity adversely affects EFH in a manner that is more than minimal and not temporary in nature"(50 CFR 610.815(a)(2)(ii)). Numerical standards for minimal or temporary effects are not provided, although the preamble to the final rule describes temporary impacts as those that are "limited in duration and that allow the particular environment to recover without measurable impact." No time scale was attached to the term 'limited duration.' The same commentary describes minimal impacts as those that "may result in relatively small changes in the affected environment and insignificant changes in ecological functions." In the EFH context, the terms 'environment' and 'function' refer to the features of the environment necessary for the spawning, breeding, feeding, and growth to maturity of the managed species and their function in providing that support.

As described in the EFH regulations, evaluation of the adverse effects of fishing on EFH is based upon the 'more than minimal and not temporary' standard. Fishing operations change the abundance or availability of certain habitat features (e.g., prey availability or the presence of living or non-living habitat structure) used by managed fish species to accomplish spawning, breeding, feeding, and growth to maturity. These changes can reduce or alter the abundance or productivity of that species, which in turn can affect the species' ability to "support a sustainable fishery and the managed species' contribution to a healthy ecosystem" (50 CFR 600.10). The outcome of this chain of effects depends on characteristics of the fishing activities, the habitat, fish use of the habitat, and fish population dynamics. Conducting an analysis that considers all relevant factors required that information from a wide range of sources and fields of study be consolidated in order to focus on the evaluation of the effects of fishing on EFH. Professional judgement had to be relied upon when scientific uncertainty regarding information necessary for analysis occurred.

The duration and degree of fishing's effects on habitat features depend on the intensity of fishing, the distribution of fishing with different gears across habitats, and the sensitivity and recovery rates of habitat features. A numeric model was developed as a tool to structure the relationships between available sources of information on these factors. This model was designed to estimate proportional effects on habitat features that would persist if current fishing levels were continued until affected habitat features reached an equilibrium with the fishing effects. At equilibrium, habitat features will neither further degrade nor improve if fishing effects persist at a constant level. Therefore, such effects would not be of limited duration and would meet the 'not temporary' test.

While subject to considerable data limitations, model results consolidate the best available information on each factor determining fishing's effects on the properties (features) that allow the waters and substrates of Alaska to serve as fish habitat. These estimates only partially address the effects of fishing on the EFH of managed species, since the model does not consider the habitat requirements of those species or the distribution of their use of habitat features. Those considerations required qualitative assessments by experts on each species. In spite of its limitations, the model provided a consistent, reasonable perception of fishing's effects on features of the habitat at the smallest feasible spatial scale. This freed the species evaluators from making individual, subjective estimates of how fishing affects habitat features, allowing them to focus on what the effects estimated by the model mean for each managed species. Specifically, the evaluators were asked to use the model output in addressing whether the fisheries, as they are currently conducted, are affecting habitat that is essential to the welfare of each managed species. In other words, are continued fishing activities at the current rate and intensity likely to alter the ability of a managed species to sustain itself over the long term?

Evaluators were provided with the maps and habitat use information developed during the EFH designation analyses. Effect estimates from the model, displayed on charts and summed across habitat types and species EFH areas, were then evaluated as to how they impact the habitat's ability to support the spawning, breeding, feeding, or growth to maturity of a managed species. The evaluation considered which habitat features are used by each managed species, the overlap of that use with the effects of fishing on those features, and other evidence relevant to whether fishing affects the EFH of each species. The distribution of fishing effects on habitat features was portrayed to the smallest scale practicable to permit consideration of effects at any sites considered vital enough to have population-level effects. Indications from historical and current stock assessments of each species' ability to maintain productivity while subject to current or higher levels of fishing intensities were also considered. The standard for evaluation was whether the expected effect on the species' ability to support a sustainable fishery or its role in a healthy ecosystem is more than minimal. Such effects were, therefore, more than minimal and not temporary, meeting the full standard requiring Council action to minimize effects of fishing on EFH.

For consistency between evaluations, as well as with the National Standards and the draft Programmatic Groundfish EIS (NMFS, 2003), the ability of each stock to stay above its minimum stock size threshold (MSST) was used as a measure of its ability to "support a sustainable fishery." The MSST is the stock level at which the ability to produce maximum sustainable yield on a continuing basis is considered jeopardized. Therefore, the ability to stay above this level measures the ability to support a sustainable fishery. No such standard was available for the species' contribution to a healthy ecosystem. However, the stock level necessary to support a sustainable fishery does ensure that substantial numbers of fish are available to serve as prey or predators to other species, as well as fulfilling other ecosystem functions. Therefore, unless the evaluating scientists knew of ecosystem functions of the species that required a higher population level, they were instructed to use ability to stay above MSST as proxy for that criterion, as well. Stocks do not actually have to drop below MSST to require Council action; the only standard is that fishing's effects be judged to impair the ability of a stock to stay above MSST.

Substantial scientific uncertainties necessitate close consideration of the appropriate weighting of evidence. The preamble to the final EFH regulations provides the following guidance for these evaluations of fishing effects on EFH. First, council action to minimize effects of fishing on EFH "is warranted to regulate fishing activities that reduce the capacity of EFH to support managed species, not fishing activities that result in inconsequential changes to the habitat." Therefore, there has to be evidence that such a reduction in capacity would occur. On the other hand, the preamble cautions against setting too high a standard for such evidence by stating that "It is not appropriate to require definitive proof of a link between fishing impacts to EFH and reduced stock productivity before Councils can take action to minimize adverse fishing impacts to EFH to the extent practicable. Such a requirement would raise the threshold for action above that set by the Magnuson-Stevens Act." Finally, the preamble gives this advice on how to weight different sources of information. "The final rule encourages Councils to use the best available science as well as other appropriate information sources when evaluating the impacts of fishing activities on EFH, and to consider different types of information according to its scientific rigor." Therefore, species evaluators had to consider the scientific basis, uncertainties, rigor of the estimates of effects on habitat features, knowledge of fish biology, distribution and use of the habitat, and the stock assessment information in determining whether effects on EFH were more than minimal and not temporary.

This evaluation does not address the direct effects of the fisheries on the fish themselves, such as catch or as bycatch. Those issues are the subject of other sections of the FMPs. The EFH regulations address adverse effects to species welfare resulting from habitat alterations. Therefore, changes in the abundance or productivity of a fish species due to direct mortalities by the fisheries are not considered adverse effects on EFH. An exception is the situation where a prey species is affected, and the habitat is essential for another managed fish species expressly because that prey species is present.

The remainder of this appendix describes the effects of fishing analysis (What effects on habitat features are not temporary?) and then the subsequent evaluation process (Do those effects on habitat have an effect on species welfare that is more than minimal?). The evaluations resulting from this process are then presented to satisfy the requirements of the EFH final rule.

B.2 Effects of Fishing Analysis

Fishing operations can adversely affect the availability of various habitat features for use by fish species. Habitat features are those parts of the habitat used by a fish species for the processes of spawning, breeding, feeding, or growth to maturity. Effects of fishing on these features are influenced by a complex combination of factors, including the following:

1. Intensity of fishing effort
2. Sensitivity of habitat features to contact with fishing gear
3. Recovery rates of habitat features
4. Distribution of fishing effort relative to different types of habitat

The goal of this analysis was to combine available information on each of these factors into an index of the effects of fishing on features of fish habitat that is applicable to issues raised in the EFH regulations.

While at least some information was available on all of these factors, it varied in quality, spatial coverage and applicability to Alaska fisheries. There was also no accepted model or analysis for relating this information to the questions posed by the EFH regulations. An initial approach was developed in April 2002 (Witherell 2002), which combined regional statistics into a gear factor, a habitat recovery factor, and a percent coverage factor for each fishery, which were then combined into two scores related to whether potential effects are minimal or temporary. A model (Fujioka 2002) was developed in May that combined this information into an estimate of the proportional reduction in a habitat feature, relative to an unfished state, if a fishery were continued at current intensity and distribution to equilibrium (effects neither increase nor decrease if continued longer). A preliminary analysis (Rose 2002), based on that model and applied on a 5 × 5 kilometer (km) spatial scale, was provided in August to aid the Council's EFH Committee in the selection of potential alternative actions to minimize adverse effects of fishing. The current analysis follows the structure of that preliminary analysis, with improvements based on input from participants in the Council process and scientists inside and outside of the National Marine Fisheries Service (NMFS).

While this analysis provides a tool for bringing disparate sources of information to bear on the evaluation of EFH, numerous limitations arose of which users should remain mindful. Both the developing state of the model and the limited quality of available data to estimate input parameters prevent a robust evaluation of habitat effects. While quantitative output may provide an impression of rigor, the results are actually subject to considerable uncertainty. Notwithstanding, it is the best tool currently available for this assessment, but is not necessarily a definitive predictor.

While some sources of input estimates are relatively good (fishing distribution), others have substantial uncertainty or come from indirect proxies. In many cases, results from other regions, with different habitats and fishing methods, were used to estimate parameters for Alaska. To facilitate evaluation of the input parameters each table includes a column of Quality Scores (QS). These are subjective assessments of the quality of information available to estimate a specific parameter on a scale of 1 to 10. A QS of 10 indicates that we have all of the information needed to confidently assess both the value and the variability of the parameter. A QS of 1 indicates that the provided parameter value has the highest uncertainty (or lowest confidence).

B.2.1 The Effect and Recovery Model

To use estimates of fishing intensity, sensitivity of habitat features and feature recovery rates in a quantitative analysis required a model relating these factors into a unified measure of the resulting effects. This section describes the derivation of that model, followed by how that model was applied to the available information.

Fishing reduces availability of a habitat feature at a rate I. I is the product of the proportion of the feature that the fishing gear contacts per time (f) and the proportion of the contacted elements that are made unavailable, due to damage, removal or mortality (q):

(1) $I = f \times q$

Assuming elements of a habitat feature can be in only two conditions: let H = the portion of the feature unaffected by fishing, h = the portion of the feature not available to species as functioning habitat, I = rate at which fishing damages or removes the feature, and ρ = rate at which the affected portion recovers to the unaffected condition and e is a constant = 2.718:

(2) $dH/dt = (- I \cdot H) + (\rho \cdot e^{-I} \cdot h)$

so that there is no net loss of habitat, i.e., H + h = constant amount (H_0). This reflects that H is decreased at a rate I and increases as h survives further effects (e^{-I}) and recovers at a rate ρ.

Setting $h = H_0 - H$ and integrating, letting $H = H_0$ and h = 0 at time = 0, resulting in:

(3) $\int dH/dt = \int(-I \cdot H + \rho \cdot e^{-I} \cdot (H_0 - H))$

(4) $H_t = H_0(Ie^{-(I+\rho S)t} + \rho S)/(I + \rho S)$, where $S = e^{-I}$

This gives the proportion of the original habitat remaining unaffected at any time t. To find the long-term result, when the rates of effect and recovery balance each other, t is set = ∞ (infinity), resulting in:

(5) $H_{equil.} = H_0 \cdot \rho e^{-I}/(I + \rho e^{-I})$

This is converted to a percentage reduction of H at equilibrium, which will be called the Long-term Effect Index (LEI), by:

$$(6)\ LEI = 100 \cdot (1 - H_{equil})$$

From this, it can be seen that LEI increases as the effect rate *I* increases, while a high recovery rate, ρ, results in lower LEIs. Table B.2-1 shows LEI for a range of combinations of *I* and ρ (and 1/ ρ = average recovery time). The balance of effect rate and recovery rate determines the proportion of habitat affected over the long term (equilibrium). Only features that recover very quickly (high ρ) could achieve a small LEI under any fishing intensity. Likewise, features that recover very slowly may have a high LEI even with small rates of fishing effects.

This use of q × f to estimate *I* assumes that habitat features are associated with particular locations and do not have substantial ability to move. Features contacted by fishing gear are reduced in the proportion available to species by the sensitivity proportion, (q). Habitat features that have been contacted recover through time and are vulnerable to subsequent contacts (reduction of the unrecovered remainder by [q]). Under this model, the fishing effort is distributed as very small sites of contact, placed randomly within the area being analyzed. Particularly over large scales, fishing effort distributions aggregate together, with small areas subject to heavy fishing and other areas with none. At finer scales, distributions tend to be more random and less patchy (Rijnsdorp et al. 1998). Therefore, this model is best applied separately to many small areas with the results summed to larger regions.

Recovery rate, ρ, reflects the rate of change of affected habitat, h, back to unaffected habitat, H. In the absence of further effects, h would decrease exponentially until all habitat was in H, the unaffected condition. The recovery time can be thought of as the average amount of time the affected habitat stays in the affected state and would equal 1/ρ (in the absence of further effects). Each habitat feature in each habitat may have different recovery times.

The results of this model (LEIs) are proportions of the original abundance of each habitat feature (H_0) remaining at equilibrium. Because this pristine amount is not known for the features and areas studied, the LEIs could not be used to calculate the actual amount of a feature remaining in an area. Instead, they represent the ability of fishing to reduce however much of each feature was present in an area as a proportional reduction. Summing of LEIs without feature distributions assumes that all locations in each habitat have equal value. Actual combined effects would be more affected by areas of high abundances than low. Therefore, accumulated LEIs will underestimate real effects a feature that was originally more abundant in heavily fished areas than in those that were fished lightly or not fished. A bias toward high effects will occur if the reverse is true. Also, because initial feature abundance was not part of the LEI calculations, LEIs were calculated for all areas that fishing occurred, including some areas where the subject feature may never have existed. This particularly affects results for features with limited distributions.

B.2.2 Analysis Process

The model was developed to provide a quantitative tool for evaluating fishing effects based on fishing intensity, sensitivity of habitat features, and rate of habitat recovery. A number of assumptions and simplifications were necessary to match model structure to the available data. These include assumptions about effect rates, habitat recovery rates, habitat distribution, and habitat utility. Another limitation of the model was the generality of available information across relatively broad categories of habitats and features. These assumptions are described in each of the following sections and their potential effects should be acknowledged in considering the results.

Table B.2-2 describes the actual calculations of fishing effects, including input data matrices, calculation steps, and output matrices. Final results appear in the LEI $_{I\,(j \bullet k)}$ matrix, which provides information on the spatial distribution of effects (by 5×5 km block and feature), and the LEI $_{(j \bullet k)}$ matrix, which summarizes effects to each habitat feature within each habitat.

To help assess the effect of the parameter uncertainty and to demonstrate the potential range of plausible effects, LEIs were calculated using high, medium, and low input values for sensitivity and recovery rates. The model was run three separate times: first with all parameter values that would yield high effect estimates, second with those for medium values, and, finally, with all values yielding low estimates combined. These upper and lower sets of estimates are not statistical confidence levels, but do provide a relative assessment of potential error in the central estimates.

The analysis initially assessed the cumulative effects of all fishing activities. The portion of those effects that could be attributed to individual fisheries were then calculated. The first analysis step ($f \times q = I$) was carried out for each fishery separately. The resulting I values were multiplied by the area of each block and summed for each feature/habitat combination, giving each fishery an area-weighted I value for each feature habitat combination. The original LEI for each feature/ habitat combination (calculated for all fisheries combined) was then apportioned between fisheries according to the area-weighted I value for each fishery. The resulting fishery LEIs indicate the amount of the overall LEI attributed to that fishery.

B.2.3 Organizational Categories for Fishing Effects Analysis

B.2.3.1 Designation and Description of Habitats

Habitat information varies in quality between regions. McConnaughey and Smith (2000) and Smith and McConnaughey (1999) described available data on sediments for the Bering Sea (BS) shelf and the relationship of that data to the distribution of flatfish. The results from this study were used to define five habitats for this analysis (Figure B.2-1). The first habitat, situated around the shallow eastern and southern perimeter of the EBS and near the Pribilof Islands, has primarily sand substrates. The second, across the central shelf out to the 200 meter (m) contour, has mixtures of sand and mud. A third, west of a line between St. Matthew and St. Lawrence Islands, has primarily mud (silt and clay) substrates, with some sand. In addition to substrate, depth is an important determinant of species distributions and presumably their use of habitat. Therefore, the EBS slope (200 to 1,000 m), with primarily sand/mud substrates, was the fourth EBS habitat used in this analysis. The areas north and east of St. Lawrence Island, including Norton Sound, which were not included in this analysis because they are subject to almost no fishing effort, have a complex mixture of substrates.

Comprehensive substrate data sets do not exist for the Gulf of Alaska (GOA). Instead, there are only a few isolated pockets of observations. The GOA has a much more complex bathymetery then the EBS, so in this analysis, GOA habitats were defined using depth and slope criteria. The following combinations, based on strata used for Alaska Fisheries Science Center (AFSC) groundfish surveys, were used in this analysis (Figure B.2-1): shallow waters (0 to 100 m), deeper waters on the shelf (100 to 300 m), and upper slope (200 to 1,000 m). Depths between 200 and 300 m were allocated to the slope only in areas where contours indicated a steep area immediately adjacent to the deeper slope depths.

The Aleutian Islands (AI) also have complex bathymetry and very limited available substrate information. Because the shelf is very narrow, AI habitats were separated into shallow (0 to 200 m) and deep (200 to 1,000 m) categories. Because its bathymetry more closely resemble the AI region than the EBS, the strip of the southern BS between 165 and 170ºE longitude and south of 54º 30" N latitude (management areas 518 and 519) were considered part of the AI region for this analysis.

Designation of substrate types is useful since much of the recovery rate and fishing effect studies are specific to particular substrates. For the EBS shelf, substrate information was used directly in defining habitat areas, making the appropriate substrate apparent. However, both the GOA and the AI have complicated mixes of substrates, including a significant proportion of hard substrates (pebbles, cobbles, boulders, and rock). Insufficient data are available to describe their spatial distributions. Each of the strata in the GOA and AI were divided into two sub-habitats, hard (pebble, cobble and rock) and soft (silt, sand and gravel) substrates.

Because distributional data are lacking, the same values for the proportions of hard and soft substrates were applied to each of the blocks in each habitat of the GOA and AI. Because better data or proxies were not available for these hard/soft proportions for the GOA habitat types, an estimate of hard/soft proportions was developed based upon the proportion of sites visited during NMFS groundfish surveys that were found to be appropriate for trawling with standard NMFS survey gear. Stations considered inappropriate for trawling for reasons unrelated to substrate hardness (steep or uneven bottoms, cable zones, or unnavigable waters) were not included. This proxy gives only a rough approximation of substrate as 1) the standard trawl may function on smoother pebble or cobble substrates that would otherwise be considered hard, 2) the trawl may be damaged by isolated boulders in predominantly soft substrates that may be mistakenly classified as hard, 3) a trawlable bottom may be found in areas of mostly hard substrate, and 4) soft bottom patches may exist in untrawlable areas but these patches may not be continuous enough to achieve a minimum trawl tow. The data set also suffers from the inconsistency of reporting between years and head survey scientists. The resulting proportions from the model were 19 percent hard substrate in the shallow stratum, 5 percent hard substrate in the deep shelf, and 10 percent hard substrate on the slope.

Trawl survey data were not similarly applicable for the AI because relatively few trawlable sites (with the standard survey trawl) have been located. It is likely that a large proportion of the AI seafloor is hard substrate. Therefore, a value of 80 percent hard substrates was used for both shallow and deep strata.

These proportional estimates of hard and soft substrates do not affect the results accumulated within habitats. LEI results reported for proportions of hard substrates are the same as would be calculated if the entire habitat area consisted of hard substrates; likewise for the soft substrate results. Proportion estimates do affect the values for individual blocks, where these estimates apportion the hard and soft LEI values for that block into a single value.

The insufficient amount of real data on the types, proportions, and distribution of substrates in the GOA and Aleutians Islands should engender great caution in the application of the analysis results for these regions. These are areas where an intensified search for relevant data and the collection of additional applicable data would significantly improve future analyses of fishing effects.

B.2.3.2 Selection of Habitat Features

The connection between fishing gear effects on habitat and resulting effects on managed species will depend on which features of the habitats were selected for analysis. Features that are not affected by fishing or do not serve a habitat function for a managed species are not relevant to the EFH analysis. Except for prey, which will be discussed separately, no information was found indicating significant effects of fishing on features of pelagic waters serving a habitat function for a managed species. Therefore, pelagic effects were assessed as minimal and not analyzed further.

In contrast, a number of studies (see Section 3.4.3) have identified effects of fishing on features of the benthic environment that may affect the welfare of managed species. For each feature category used, estimates of sensitivity to fishing gears and recovery rates were derived from the literature. The limited number of relevant effect and recovery studies and the minimal amount of data pertaining to use of habitat features by managed species reduced the consideration of habitat features to broad categories.

Fishing effects have been demonstrated for a variety of organisms that are prey for managed species. These were divided into the categories of infaunal and epifaunal prey. Effects have also been documented for features providing seafloor structure that may be used by fish (particularly juveniles) for spawning/breeding purposes or as shelter from predators, particularly juveniles. These features were divided into the classes of living and non-living structure. A special category of living structure, comprised solely of hard corals, was analyzed separately due to indications of very slow recovery rates. The organisms and structures making up infaunal prey, epifaunal prey, living structure, and non-living structure vary between different habitat types. Separate sensitivity and recovery rates were derived and applied to each. The analysis treated each habitat feature class separately for each habitat type, so substrate structure in rocky habitats was not compared directly to substrate structure in sandy habitats.

B.2.3.3 Definition of Fisheries and Description of Gear Used

Data from the NMFS observer program provided detailed information on the distribution and intensity of the effort by groundfish fisheries off of Alaska (Section 3.4.1). For each gear type, a vessel is assigned to a fishery based on the species making up the largest proportion of the total catch for the week. The fisheries of each region are listed in Table B.2-3. The groundfish fisheries use bottom trawls, pelagic trawls, longline gear and pots. A NMFS workshop in March 2002 generated good descriptions of the gear used by each of the fisheries off of Alaska (see Section 3.4.1). These descriptions were very useful in deriving the areas covered by a unit of effort for each fishing gear type and in appropriately applying the available research on gear effects.

Groundfish vessels less than 60 feet in length are not required to carry observers and are not represented in the observer data. The fleets of trawl and longline vessels under 60 feet each take less than 1 percent of the groundfish catch, so their exclusion from the analysis was not considered likely to significantly change the evaluation. Therefore, these fisheries were not considered.

An initial analysis prepared by the North Pacific Fishery Management Council (Council) staff (Witherell 2002) and reviewed at the May 2002 EFH Committee meeting, indicated that groundfish fisheries represented all but a small fraction of the potential fishing effects on habitat. This analysis generated scores for each fishery similar to the LEI scores described above. Scallop, BSAI crab, and salmon fisheries had negligible effects on EFH, with overall scores for each of these fisheries less than 0.1. For comparison, the analysis found that the groundfish fisheries had LEI scores for trawl fisheries ranging from 0.2 to 11.2. Based on the following evaluations, the non-groundfish fisheries were not included in the final detailed analysis.

For the scallop fishery, the Witherell analysis found that although the effects of this gear on benthic habitats are greater than for other gear types, the fishery occurs in areas and habitat types that have relatively fast recovery rates. Additionally, the overall footprint (area effected annually) of the scallop fishery is very small (149 square nautical miles [nm]), equating to about 0.1 percent of the total available benthic EFH area. The effects of this fishery are concentrated in a very small proportion of EFH, and thus these effects are considered minimal and temporary in nature.

For the BSAI crab fisheries, the analysis found that the fisheries have an extremely small overall footprint, totaling less than 1 square nm per year, equating to less than 0.0007 percent of the total available benthic EFH area. The effects of this fishery are concentrated in an extremely small proportion of available EFH, and, thus, these effects are considered minimal and temporary in nature.

For the salmon fisheries, the analysis found that the effects on EFH are almost non-existent because the gear generally never touches benthic habitats. Only the drift gillnet fishery was found to have an overall coverage of more than 0.1 percent of available EFH, but because the gear never touched the bottom, this fishery could not affect benthic EFH. Thus, the effects on benthic EFH of the Alaska salmon fisheries are considered minimal and temporary in nature.

B.2.4 Parameter Estimates

B.2.4.1 Fishing Intensity (f) (by 5 km × 5 km blocks)

High quality fishing effort data are available from the groundfish observer program (see Section 3.4.1). Individual sets were tallied for 5 x 5 km blocks for the years 1998 to 2002. This 5-year period was selected to represent the current level of fishing effects. Reported effort (duration for trawls, hooks for longlines, and pot drops for pots) was converted into swept areas. Trawl durations were multiplied by speed, trawl width, and proportion of effort on the bottom (Table B.2-4). Width and speed were estimated using a survey of trawlers on gear usage and from information collected by observers. The estimate for the proportion of pelagic trawl effort contacting the seafloor considered both the amount of time in which any part of the trawl contacted the seafloor and the width of trawl contact with the seafloor during different periods of the fishery (e.g., day/night, A and B seasons). Information for this estimate was provided by fishing organizations. As the vulnerability of pelagic trawls to damage precludes their operation on rough and hard substrates, bottom contact was set at zero for the hard bottom habitats of the Gulf of Alaska and the Aleutians.

For long line and pot fisheries, different methods were used. In reporting effort for the longline fishery, two factors were taken into account, the number of longline hooks multiplied by length of line per hook, and the side-to-side extent or movement of the line. Pot drops were multiplied by the width of the pot and an estimate of the average distance traveled by pots across the seafloor. Effort values for vessels not subject to 100 percent observer coverage were extrapolated from an estimate of the proportion of effort that was observed for that fishery and vessel class. While extrapolations for unobserved effort accounted for the total quantity of effort, they could not account for any differences in the geographic distribution of observed and unobserved effort. The values used for each of these swept areas for trawl, longline, and pot fishing, are presented in Table B.2-4, along with comments on the source and quality of the estimates. No direct observational data were available for longline effect width, pot movement distance, or the proportion of pelagic trawl effort contacting the bottom, so each value has some uncertainty.

Fishing effort data from the observer database were assigned to 5 km × 5 km blocks based on the ending position of the tow, set, or string. The total area covered by the effort was assigned to each block (in square km [km^2]). This total area of effort was divided by the area of the block (25 km^2) and by the number of years (5) to derive an intensity index.

Consequences of assigning effort to blocks using this method include the following:

1) Some effort assigned to each block may actually extend into neighboring blocks because effort was assigned to blocks based on ending positions. In areas of similar intensity, most of the effort will be balanced by offsetting exchanges of effort between blocks. More noticeable errors may occur along

boundaries or around isolated cells. However, large-scale patterns will not be substantially affected because no effort is moved farther than the length of a single tow. Averaging across years will also tend to mute the effects of these small-scale effort displacements.

2) The raw average intensities do not account for uneven distribution of effort within blocks. While this simple ratio could be incorrectly interpreted as an equal number of contacts at every site in the block, actual fishing patterns are more likely to repeatedly contact previously fished sites (overlap) than such a simple uniform distribution. Overlapped effort has less total effect because habitat features removed by previous passes are no longer present. It also increases the likelihood that more of the area of a block will not be contacted. The analysis model treats all effort locations as independent, mimicking a random effort distribution. This accounts for the effects of overlap as long as no sites are preferentially targeted.

3) Even on scales smaller than 25 km^2, fishing effort would still be expected to focus on more productive areas and leave some other areas untouched. Since fish, and hence the fisheries that harvest them, tend to aggregate, even at small scales, the random distribution probably underestimates the proportion of effort overlap occurring in the fisheries and hence overestimates habitat effects. The localization of fishing effort and the habitat effect per contact determine the size of any such error.

4) Patchy distributions of fishing efforts, both within and between blocks, will produce different effects at different locations. Since the habitat features and their use by fish can also be patchy, the actual effects on habitat function are influenced affected by how fishing and habitat-use patterns correspond. High overlap of habitat-use and fishing would produce underestimates of habitat effects, while separation between patterns would produce overestimates. Underestimates would be most likely for features used by adult fish that are targeted by the fisheries. Overestimates are more likely for features used by other age classes, where their distribution is different from adults, or for habitat features that occur in areas that are difficult to fish, such as those with very rough, hard seafloors.

B.2.4.2 Sensitivity (q)

As a recent National Academy of Sciences review stated, there have been numerous recent studies on the effects of fishing gear on seafloor habitats with the most studied gear type being bottom trawls. Estimates from those studies, using gear relevant to Alaska fisheries (see Section 3.4.3), were used to generate sensitivity parameters. Information on other gears, except scallop dredges, is extremely limited. Sensitivity parameters for these gears were assigned using professional judgement.

The most relevant studies were selected to estimate q, the proportion by which habitat function at a particular site is reduced by a single contact with each type of fishing gear. The results of the literature review were compared and combined, taking into account differences in methods, applicability to Alaska fisheries, and the habitats and habitat features studied. Where available, measurements of q from both statistically significant and non-significant results were considered. Thus, this summary analysis does not directly consider the variability from the individual studies. Instead, the sampling unit was defined as a single study result (i.e., one reduction estimate for one species from one study). While weighting by the variability of each estimate would have been preferable, this information was rarely available. Since the statistical distribution of these relatively sparse data were unknown, medians were used to represent the central tendencies of these data results. To allow consideration of the effects of variability on estimates, the 25th and 75th percentiles were also calculated and used to estimate the effects of fishing. Only studies where q could be directly estimated were used in the analysis. This requirement meant the number of gear contacts was known or could be estimated. Another requirement was that sufficient time for recovery to occur had not elapsed. Applicable studies where these requirements were not met were examined for consistency with the results of the studies used.

The gear effects model requires estimates of q and allows these estimates to be specified for each combination of fishing activity, habitat type, and habitat feature. To the extent that different effects can be identified for different components of a fishing gear, the effect rates were averaged after weighting the proportion of each gear component's contact with the seafloor.

While the goal of sensitivity estimation was to estimate changes in habitat function, this parameter is not directly measurable. A measurable property of the habitat features, such as the feature's abundance or condition, had to be used as a proxy for the level of function. Changes in the available biomass of different prey species were used as a proxy for feeding functions. Structure functions, most importantly those related to the survival of juveniles to maturity, were more difficult to assess. While abundance of structure-providing species remaining after trawling was available as a proxy, the decrease in function of damaged organisms (clearly an important consideration) could not be quantitatively assessed with any confidence. A decrease in function of 50 percent was applied to estimate the decrease in function of damaged organisms for this analysis. Values available from studies that indicated mortality resulting from a portion of an organism being damaged were added to the estimates of decreased function for structure-providing organisms. Suitable proxies were less available for non-living substrates.

In estimating the effects of a single gear contact, as required for this analysis, it was necessary to extrapolate results from studies that combined the effects of several contacts. The analysis assumes that the effects of all gear contacts are independent; that is, that a second contact decreases habitat function by the same proportion as the first contact. In reality, absolute reduction is less with each subsequent contact because less habitat function is available for removal. The method to adjust for multiple contacts in a study followed that same assumption.

Therefore, the ratio of features present before n gear contacts (H_b) and after n gear contacts (H_a) is:

$$(7)\ H_a/H_b = (1\text{-}q)^n,$$

where q is the proportional reduction in habitat per gear contact and n is the number of contacts. Solving for q gives:

$$(8)\ q = 1 - e^{(\ln(Ha/Hb)/n)},$$

which was used to adjust the total reduction estimates from studies using multiple contacts with the gear.

B.2.4.2.1 Bottom Trawls

Infaunal Prey

Infaunal organisms, such as polychaetes, other worms, and bivalves, are significant sources of prey for Alaska groundfish species. Because we were not able to determine which crustaceans cited in trawl effects studies were actually infauna, all crustaceans were categorized as epifaunal prey. Studies of the effects of representative trawl gear on infauna included Kenchington et al. (2001), Bergman and Santbrink (2000), Brown (2003), Brylinsky et al. (1994), and Gilkinson et al. (1998).

Kenchington et al. (2001) examined the effects on over 200 species of infauna from trawl gear that closely resembled the gear used off of Alaska. Three separate trawling events were conducted at intervals approximating 1 year. Each event included 12 tows through an experimental corridor, resulting in an average estimate of three to six contacts with the seafloor per event. Of the approximately 600 tests for species effects conducted, only 12 had statistically significant results. The statistical methods were biased toward Type 1 error of incorrectly concluding an impact. Ten of the significant results are from a year when experimental trawling was more concentrated in the center of the corridors where the samples of infauna were taken. It is likely that more trawl contacts occurred at these sampled sites than the 4.5 estimate (average of three to six contacts) used to adjust the multiple contact results. As such, the results that were available from the study (non-significant values were not provided) represent a sample biased toward larger reductions when used to assess median reductions of infauna. The resulting median effect was 14 percent reduction in biomass (Table B.2-5).

Bergman and Santbrink (2000) studied effects on infauna (mostly bivalves) from an otter trawl equipped with 20 centimeter [cm] rollers in the North Sea. Because the study was conducted on fishing grounds with a long history of trawling, the infaunal community may already have been affected by fishing. Experimental trawling was conducted to achieve average coverage of 1.5 contacts within the experimental area over the course of the study. Results were provided for two subtrate types: coarse sand with 1 to 5 percent of area contacted; and silt and fine sand with 3 to 10 percent of area contacted. The five infauna biomass reductions in the first area had a median of 8 percent. The ten infauna biomass reductions from the second area had a median of 5 percent.

A recent master's thesis, Brown (2003), studies the effects of experimental trawling in an area of the nearshore EBS with sandy sediments. Trawling covered 57 percent of the experimental area. Several bivalves had lower abundance after trawling, while polychaetes were less affected. The median of the reduction in percentages for each species, after adjusting for coverage, was a 17 percent reduction in biomass per gear contact.

Brylinsky et al. (1994) investigated effects of trawling on infauna, mainly in trawl door tracks, at an intertidal estuary. Only three results were provided for infauna in roller gear tracks, but the results were so variable (-50 percent, +12 percent, +57 percent) that they were useless for the purpose of this analysis. Eight results on the effects of trawl doors on species biomass were available for polychaetes and nemerteans. These results had a median of 31 percent reduction in biomass and a 75th percentile of 42 percent reduction in biomass. Gilkinson et al. (1998) used a model trawl door on a prepared substrate to estimate that 64 percent of clams in the door's path were exposed after one pass, but only 5 percent were injured. Doors make up less than 4 percent of the area of the seafloor contacted by Alaska trawls.

The results of Kenchington et al. (2001), Bergman and Santbrink (2000), and Brown (2003) were combined for inclusion in the model, resulting in a median of 10 percent reduction in biomass per gear contact for infaunal species due to trawling, and 25th and 75th percentiles of 5 and 21 percent, respectively (Table B.2-5).

Epifaunal Prey

Epifaunal organisms, such as crustaceans, echinoderms, and gastropods, are significant prey of Alaska groundfish species. However, one of the most common classes of echinoderms, asteroids, are rarely found in fish stomachs. While some crustaceans may be infauna, an inability to consistently identify these species resulted in all crustaceans being categorized as epifaunal prey. Studies of the effects of representative trawl gear on epifauna included Prena et al. (1999), Brown (2003), Freese et al. (1999), McConnaughey et al. (2000), and Bergman and Santbrink (2000).

Prena et al. (1999), a component of the Kenchington et al. (2001) study, measured the effects of trawling on seven species of epifauna. The median of these results was a 4 percent biomass reduction per gear contact. There appeared to be immigration of scavenging crabs and snails in this and other studies. Removing crab and snails left only two measurements, 6 and 7 percent reductions in biomass. Bergman and Santbrink (2000) measured effects on four epifaunal species in the experimental coarse sand area (median reduction in biomass was 12 percent) and five epifaunal species in the experimental fine sand area (median reduction in biomass was 16 percent). When crabs and snails were removed, the coarse sand area was unchanged and the median value for the fine sand area was 15 percent biomass reduction. Brown (2003) studied six epifaunal species, resulting in a median reduction in biomass per gear contact of 5 percent. Combining results from Prena et al. (1999), Brown (2003), and Bergman and Santbrink (2000), and removing crabs and snails, gives a median reduction in biomass of epifaunal species of 10 percent, and 25th and 75th percentiles of 4 and 17 percent, respectively. These are the q values used for the analysis of the effects of full trawls on epifaunal prey, except for those fisheries using tire gear (see below).

The study of McConnaughey et al. (2000), compared the effects of fishing on an area that received heavy fishing pressure between 4 and 8 years previously, using an adjacent unfished area as a control. Therefore, results included a combination of species reductions and recovery, were not adjusted for multiple contacts and, therefore, were not directly comparable to the results of the studies above. However, for comparison with previously discussed studies, the resulting median and 75th percentile reductions in biomass for six species of epifauna (excluding snails and crabs) were 12 and 28 percent, respectively. The median result was within the same range as those from the more direct studies, and the 75th percentile result was not sufficiently higher as to indicate substantial error in the direct estimates.

Freese et al. (1999) studied the effects of tire gear on the epifauna of a pebble and boulder substrate. Eight epifaunal species gave a median response of 17 percent reduction in biomass and a 75th percentile of 43 percent reduction in biomass. Before snails were removed, the 25th percentile indicated an increase in biomass of 82 percent due to colonization by snails. The resulting values when two snail taxa were removed were 38 and 43 percent median and 5 percent reduction in epifaunal biomass for the 75th and 25th percentiles. The authors noted a strong transition to apparently smaller effects outside of the direct path of the tire gear. For fisheries in hard bottom areas, where tire gear is most common, epifaunal effects were adjusted for this increased effect within the path of the tire gear. Typical tire gear covers about 25 percent of the full trawl path (i.e., 14 m out of 55 m total), so the resulting q values are 17 percent reduction in epifaunal biomass for the median ($0.25\times38+0.75\times10$), 23 percent reduction for epifaunal biomass for the 75th percentile ($0.25\times43+0.75\times17$), and 5 percent reduction for the 25th percentile.

Living Structure

Organisms that create habitat structure in Alaska waters include sponges, soft and stony corals, anemones, and stalked tunicates. Studies of the effects of representative trawls on these groups include Van Dolah et al. (1987), Freese et al. (1999), Moran and Stephenson (2000), Prena et al. (1999), and McConnaughey et al. (2000). The first three studies examined the effects on epifauna on substrates such as pebble, cobble, and rock that support attached erect organisms, while the last two studies were located on sandy substrates. Effect estimates were available for only one type of structure-providing organism, the soft coral *Gersemia*, from Prena et al. (1999). After adjustment for multiple contacts, *Gersemia* had a q of 10 percent reduction in biomass per gear contact.

Both the Van Dolah et al. (1987) and Freese et al. (1999) studies identified removal rates and rates of damage to organisms remaining after contact, raising the question of how damage incurred from contact with gear reduces the structural function of organisms. In Freese et al. (1999), sponges were indicated as damaged if they had more than 10 percent of the colony removed or tears were present through more than 10 percent of the colony length. Van Dolah et al. (1987) classified organisms as heavily damaged (more than 50 percent damage or loss) or lightly damaged (less than 50 percent damage or loss). Lacking better information, the "damaged" organisms from Freese et al. (1999) were assigned a 50 percent loss of structural function and VanDolah et al. (1987) "heavily" and "lightly" damaged organisms were assigned 75 and 25 percent losses of their function respectively.

Adjustments to the Freese et al.(1999) results were based on observations of a further decrease in vase sponge densities 1 year post-study. Freese (2001) indicates that some of the damaged sponges had suffered necrotization (decay of dead tissues) to the extent that they were no longer identifiable. This percentage was added to the category of removed organisms, resulting in q estimates for epifauna structures in the path of tire gear of a 35 percent median reduction in biomass per contact and a 75th percentile of 55 percent reduction in biomass per contact. Summary results of the VanDolah data show a median of 17 percent reduction in biomass per gear contact and a 75th percentile of 22 percent reduction in biomass per gear contact. Moran and Stepheson (2000) combined all erect epifauna taller than 20 cm and studied their reductions subsequent to each of a series of trawl contacts. They estimated a per contact reduction in biomass (q) of 15 percent. Combining the non-tire gear studies gives a full gear q median per contact reduction estimate of 15 percent and a 75th percentile per contact reduction estimate of 21 percent. Using the same methods as applied to epifauna for combining non-tire gear data with the tire gear data produced effect estimates for trawls using tire gear of a median per contact reduction of 20 percent and a 75th percentile per contact reduction of 30 percent.

Data from McConnaughey et al. (2000), combining initial effects of high-intensity trawling and recovery, had a median value for structure-forming epifauna per contact reduction of 23 percent and a 75th percentile reduction of 44 percent. While these results show greater reductions than the single pass estimates from the other studies, the effects of multiple years of high-intensity trawling can reasonably account for such a difference, and thus the above values for q were not altered.

Hard Corals

While a number of studies have documented damage to hard corals from trawls, only one (Krieger 2001) was found that related damage to a known number of trawl encounters. Fortunately, this study occurred in the GOA with a common species of gorgonian coral (*Primnoa rubi*) and with gear not unlike that used in Alaska commercial fisheries. Krieger took a submersible to observe a site where large amounts of *Primnoa* were caught during a survey trawl. An estimated 27 percent of the original volume of coral was removed by the single trawl effort. The site was in an area closed to commercial trawling, so other trawling effects were absent. This value was used for coral sensitivity in the analysis bracketed by low and high values of 22 and 35 percent.

Non-living Structure

A variety of forms of the physical substrates in Alaska waters can provide structure to managed species, particularly juveniles. These physical structures range from boulder piles that provide crevices for hiding to sand ripples that may provide a resting area for organisms swimming against currents. Unfortunately, few of these interactions are understood well enough to assess the effects of substrate changes on habitat functions. A number of studies describe changes to the physical substrates resulting from the passage of trawls. However, there is no consistent metric available to relate the use of such structures by managed species to their abundance or condition. This lack of relationship effectively precludes a quantitative description of the effects of trawling on non-living structure. The following discussion describes such effects qualitatively and proposes preliminary values of q for the analysis.

Sand and Silt Substrates:
Schwinghamer et al. (1998) described physical changes to the fine sand habitats caused by trawling as part of the same study that produced Prena et al. (1999) and Kenchington et al. (2001). Door tracks,

approximately 1 m wide and 5 cm deep were detected with sidescan sonar, adding to the surface relief of the relatively featureless seafloor. Finer scale observations, made with video cameras, indicated that trawling replaced small hummocky features a few cm tall with linear alignments of organisms and shell hash. A dark organic floc that was present before trawling was absent afterwards. While no changes in sediment composition were detected, measurements of the internal structure of the top 4.5 cm of sediment were interpreted to indicate loss of small biogenic sediment structures such as mounds, tubes, and burrows. Brylinsky et al. (1994) describe trawl tracks as the most apparent effect of trawls on a silty substrate and describe the tracks of rollers as resulting in much shallower lines of compressed sediment than tracks of trawls without rollers. A wide variety of papers describe trawl marks, including Gilkinson et al. (1998), who describe the scouring process in detail as part of a model door study.

For effects on sedimentary forms, the action of roller gear trawls replaces one set of cm-scale forms, such as hummocks and sand ripples, with door and roller tracks of similar scales. In habitats with an abundance of such structures, this can represent a decrease in seabed complexity, while in relatively smooth areas, an increase in complexity will result (Smith et al. 2000). The effects on internal sediment structure are considered too small in scale to directly provide shelter to the juveniles of managed species. The extent to which they affect the availability of prey for managed species is better measured by directly considering the abundance or those prey species. This consideration was done by studies cited in the prey sections above. Since the observed effects of a single gear contact are relatively subtle with ambiguous effects on function, the parameter selected for this analysis represents a small negative effect (-2 percent). This provides some effect size that can be scaled up or down if greater or lesser effects are hypothesized or measured.

Pebble to Boulder Substrates:
In substrates composed of larger particles, large pebbles to boulders, the interstitial structure of the substrate has a greater ability to provide shelter to juveniles and adults of managed species. The association of species aggregations with such substrates provides evidence of their function as structure (Krieger 1992, 1993). Freese et al. (1999) documented that the tire gear section of a trawl disturbed an average of 19 percent of the large boulders (more than 0.75 m longest axis) in its path. They note that displaced boulders can still provide cover, while the breaking up of boulder piles can reduce the number and complexity of crevices.

In areas of smaller substrate particles (pebble to cobble), the track of the tire gear was distinguishable from the rest of the trawl path due to the removal of overlying silt from substrates with more cobble or the presence of a series of parallel furrows 1 to 8 cm deep from substrates with more pebble. Of the above effects, only breaking up boulder piles was hypothesized to decrease the amount of non-living functional structure for managed species. A key unknown is the proportional difference in functional structure between boulder piles and the same boulders, if separated. If that difference comprised 20 percent of the functional structure and 19 percent of such piles were disturbed over one-third of the trawl paths (tire gear section), a single trawl pass would reduce non-living structure by only about 1 percent. Even if piles in the remaining trawl path were disturbed at half the rate of those in the path of the tire gear (likely an overestimate from descriptions in Freese et al. 1999), the effect would only increase to 2 percent. Lacking better information, this speculative value was applied in the analysis.

B.2.4.2.2 Pelagic Trawls

Studies using gear directly comparable to Alaska pelagic trawls, and thus identifying the resulting effect of such gear contact with the seafloor, are lacking. By regulation these trawls must not use bobbins or other protective devices, so footropes are small in diameter (typically chain or sometimes cable or wrapped cable). Thus, their effects may be similar to other footropes with small diameters (i.e., shrimp or

Nephrops trawls). However, these nets have a large enough mesh size in the forward sections that few, if any, benthic organisms that actively swim upward would be retained in the net. Thus, benthic animals that were found in other studies to be separated from the bottom and removed by trawls with small-diameter footropes, would be returned to the seafloor immediately by the Alaska pelagic trawls. Pelagic trawls are fished with the doors that do not contact the seafloor, so any door effects are eliminated. Finally, because the pelagic trawl's unprotected footrope effectively precludes the use of these nets on rough or hard substrates, they do not affect the more complex habitats that occur on those substrates.

Two studies of small footrope trawls were used to represent the effects of pelagic trawl footropes on infaunal prey. Since most infaunal prey are too small to be effectively retained by bottom trawls, the large mesh size of pelagic trawls was not considered a relevant difference for the feature. Ball et al. (2000) investigated the effects of two tows of a Nephrops trawl in the Irish Sea on a muddy sand bottom in 2 different years. Eighteen taxonomic groups were measured in each year, including bivalves, gastropods, crustaceans, and annelids. For the 27 abundance reductions cited, the median effect was 19 percent reduction abundance per gear contact and the 75th percentile was 40 percent reduction in abundance per gear contact, with the adjustment for multiple tows. Sparks-McConkey and Wating (2001) used four passes of a whiting trawl on a clay-silt bottom in the Bay of Maine. The infauna responses measured included three bivalves and seven polychaetes and nemerteans. The median response was a 24 percent reduction in abundance per gear contact and the 75th percentile was 31 percent reduction in abundance per gear contact, with the adjustment for multiple tows. Combining the two studies gave a median per contract reduction of 21 percent and a 75th percentile per contact reduction of 36 percent. These values were higher than those for roller gear trawls since there is continuous contact across the footrope and a greater ability of smaller footropes to penetrate the substrate.

Sessile organisms that create structural habitat may be uprooted or pass under pelagic trawl footropes, while those that are more mobile or attached to light substrates may pass over the footrope, with less resulting damage. Non-living structures may be more affected by pelagic trawl footropes than by bottom trawl footropes because of the continuous contact and smaller, more concentrated, surfaces over which weight and towing force are applied. In contrast, bottom trawls may capture and remove more of the large organisms that provide structural habitat than pelagic trawls because of their smaller mesh sizes. The bottom trawl doors and footropes could add complexity to sedimentary bedforms as mentioned previously, while pelagic trawls have an almost entirely smoothing effect. Based on these considerations, values of 20 percent reduction per gear contact and 30 percent reduction per gear contact were selected for both living and non-living structure.

B.2.4.2.3 Longlines

Studies were not found that quantitatively assess the effects of longlines on seafloor habitat features. Due to the light weight of the lines used with longline gear, effects on either infaunal or epifaunal prey organisms are considered to be limited to the effects of anchors and weights. Since these components make up less than 1/500th of the length of the gear, effects of these anchors and weights are considered very small (0.05 percent reduction per contact was the value used). In a similar manner, effects on the non-living structure of soft bottoms are also likely to be very small.

Organisms providing structure may be hooked or otherwise affected by contact with the line. Observers have recorded anemones, corals, sea pens, sea whips and sponges being brought to the surface hooked on longline gear (Stellar sea lion protection measures SEIS, 11/01), indicating that the lines move some distance across the seafloor and can affect some of the benthic organisms. The effects on non-living structure in hard bottom areas due to hang-ups on smaller boulder piles and other emergent structures is limited to what may occur at forces below those necessary to break the line. Similar arguments to those used for bottom trawl effects on hard non-living structure would justify an even lower effect than the value generated for bottom-trawling (1 percent). Unfortunately, there are no data to indicate what proportion the retained organisms represent of those contacted on the seafloor or the level of damage to any of the affected organisms. Values for reduction of living structure equal to one-half of those for bottom trawls were used for the area contacted by longlines.

B.2.4.2.4 Pots

The only studies on pots (Eno et al. 2001) have examined gear much smaller and lighter than that used in Alaska waters and are thus not directly applicable in estimating effects of pots on habitat. Alaska pots are approximately 110 times as heavy and cover 19 times the area as those used by Eno et al. (2000) (2.6 kg, 0.25 m^2). The Eno et al. (2000) study did show that most sea pens recovered after being pressed flat against the bottom by a pot. Most Alaska pots have their mesh bottoms suspended 2.5 to 5 cm above their weight rails (lower perimeter and cross pieces that contact the substrate first), hence the spatial extent to which the greater weight of those pots is applied to organisms located underneath the pots is limited but more intense.

The area of seafloor disturbed by the weight rails is of greatest concern, particularly to the extent that the pot is dragged across the seafloor by bad weather, currents, or during hauling. Based on the estimated weight in water of the pots, and the surface area of the bottom of these rails, the average pressure applied to the seafloor along the weight rails (about 1 pound per square inch [lb/in^2] [0.7 kilograms per square centimeter (07 kg/cm^2)]) is sufficient to penetrate into most substrates during lateral movement. The effects of pots as they move across the bottom were speculated to be most similar to those of pelagic trawls with smaller contact diameter and more weight concentrated on the contact surface. Therefore, structure reduction values 5 percent greater than those determined for pelagic trawls were used.

B.2.4.3 Recovery Rate

A small proportion of studies on the effects of fishing have looked at recovery periods for different features and habitat types. Most of these studies were summarized in Collie et al. (2000). This paper contained plots that combined results from studies that examined many gear types, including intertidal dredges, scallop dredges, beam trawls, and small footrope trawls. Nearly all of the organisms represented in the plots are from groups that are classified as infaunal or epifaunal prey. The only points in the plots representing living shelter are from the Van Dolah et al. (1987) study. The logarithmic time scale used for the figures in that paper make it somewhat difficult to extract exact recovery periods. Careful measurements and known landmarks (i.e., there was generally a recognizable group of studies with periods of 1 year in all plots) were used to achieve the following estimates. Fishing effects in sand habitats were reduced to very near zero effect within about 2 months, though a small amount of reduction in biomass remained until 1 year. Therefore, the estimated timeframe for recovery in sand habitats was 3 months or 0.25 year (Table B.2-5) to account for the small reduction over time. Mud/sand mixes and mud habitats were estimated to recover at 12 months and 6 months, respectively. Studies using roller trawls in those environments included Kenchington et al. (2001), which detected no remaining effects in a sand/mud mix after 1 year; and Brylinski et al. (1994) with polychaetes and nematodes in intertidal sand/mud mixes recovering in 1 to 2 months. The recovery period selected for sand/mud mixes was 0.75 years and for mud habitats was 1 year.

To allow for evaluation of scientific uncertainty, the same data were considered to derive long and short recovery times for each habitat. The resulting values were 3 to 4 months for sand, 6 to 12 months for sand/mud, and 6 to 18 months for mud habitats. The inverses of all of these values were calculated to estimate the recovery rates needed for the effect model (Table B.2-6).

In general, very little data are available on the recovery periods for living structure. A literature review to determine growth rates, recovery rates, fecundity values, and recruitment rates for major “structuring invertebrate” taxa (sponges, hard and soft corals, bivalves, hydroids, polychaetes, anemones, sea pens, and bryozoans) from previous studies was undertaken. There was minimal information on most of these taxa from studies conducted in Alaska and few studies from temperate or arctic waters in general. Preliminary data were available for EBS anemone populations, which indicated the recovery rate of sea anemones from trawling effects may have been as great as 30 percent per year in soft bottom habitats ®. McConnaughy 2003). This finding was consistent with the Wahl (1985) study in temperate waters. In hard bottom areas of the GOA, Freese (2001) returned to an area affected by tire gear and found no visible indications of healing or regrowth of vase sponges. A study gave a recovery rate for gorgonian corals of about 4 percent per year in a marine sanctuary in Florida (Gittings et al. 1988). In Alaska, gorgonian growth rates have been observed to be 0.2 and 0.58 cm per year (Stone and Wing 2001, Andrews et al. 2002), indicating a 1-m-high coral could be in excess of 100 years old. An evaluation of maximum ages, growth rates and recruitment rates for bivalves and polychaetes suggested their recovery times could be shorter than recovery times for corals, sponges, and anemones. VanDolah et al. (1987) found full recovery of sponges and octocorals in less than 1 year in a shallow water study off of North Carolina.

A meeting was scheduled with a panel of experts to discuss and estimate recovery rates of structure-forming invertebrates that would be acceptable to use in the fishing effects model. The participants included scientists that had previously studied invertebrate taxa. Attendees were Braxton Dew (RACE), Linc Freese (ABL), Bob McConnaughey (RACE), Chris Rooper (RACE), Craig Rose (RACE), Matt Wilson (FOCI), Bruce Wing (ABL), Cynthia Yeung (RACE) and Mark Zimmermann (RACE). In advance of the meeting, the literature review of growth rates, recovery rates, fecundity values, and recruitment rates for “structuring invertebrate” taxa was circulated among the scientists. This life history information served as background information for determining the potential recovery of these invertebrates. There was consensus that a reasonable range for recovery rates of structure-forming invertebrates associated with the soft bottom, based on their life history characteristics, was 10 to 30 percent per year with a mean of 20 percent per year. There was also consensus that hard bottom recovery rates were slower, 1 to 9 percent per year, with a mean of 5 percent per year based on hard bottom invertebrate life history characteristics. These were converted to exponential rates for use in the model by the following formula:

$$\rho = \ln (1\text{+annual percent increase}).$$

Resulting values were 0.26 years, 0.18 years, and 0.10 years for soft substrate habitats; and 0.09 years, 0.05 years and 0.01 years for hard substrate habitat.

Recovery rates of gorgonian corals are potentially much longer and therefore will be evaluated separately in the analysis. Short, middle, and long recovery periods of 50, 100, and 200 years were the values used for gorgonian corals.

Recovery of non-living structures can occur from current and wave action or burrowing animals. Studies indicated that door marks had became undetectable within 2 to 4 months (Brylinski et al. 1994) or 1 year (Schwinghamer et al. 1998), and other marks dissipated more rapidly. Therefore the recovery rate for soft substrates was determined to be 1 year for the purposes of the model. In hard substrates, the breaking up of boulder piles is not an effect that will recover on biological time scales, but disturbances of pebble size substrates could be modified by biological action. The effect/recovery model is not a good fit for this type of habitat feature. While boulder pile habitat will not recover, the total effect possible is the difference between the habitat value of the piles and the habitat value of the same boulders when isolated.

Past that point, no further degradation of that feature could occur, although the model continues to apply proportional reductions beyond that point. This is an area where more detailed information on habitat usage, description, and distribution is needed. For purposes of this analysis, a recovery period of 100 years, with a range of 50 to 200 years, was used to capture recovery of pebble site substrates.

B.2.4.4 Habitat Categorization

The habitat and regional boundaries (see B.2.3.1) were overlayed using geographical information systems (GIS) (ArcMap), resulting in the classification of each of the 5 × 5 km blocks by habitat type. Where a boundary passed through a block, the area within each habitat was calculated and those areas were analyzed separately. For the GOA and AI habitats, the estimates of proportions of hard and soft substrate habitat types were entered into the classification matrix for each block.

B.2.4.5 Area (A)

The total area of each benthic habitat was calculated through GIS based on coastlines, regional boundaries, habitat boundaries, and depth contours (Table B.2-7).

B.2.5 Results of the Analysis of Effects of Fishing on Habitat Features

This analysis estimated the spatial distribution of the effects of fishing on infaunal prey, epifaunal prey, living structure (coral treated separately), and non-living structure across different habitats and between fisheries using a long-term effect index (LEI). The LEI estimated the percentage by which these habitat features would be reduced from a hypothetical unfished abundance if recent intensity and distribution of fishing effort were continued over a long enough term to achieve equilibrium. Equilibrium is defined as a point where the rate of loss of habitat features from fishing effects equal the gain from feature recovery. The spatial pattern of long-term effect indices largely reflects the distribution of fishing effort scaled by the sensitivity and recovery rates assigned to different features in different habitat types. Thus, patterns on the charts of LEI for each feature class were very similar, with higher overall LEIs for more sensitive or slower recovering features (Figures B.2-2 to B.2-5). Prey LEIs were substantially lower than structure LEIs, reflecting their lower sensitivity and faster recovery rates.

All habitats included substantially unfished and lightly fished areas that have low LEIs (less than1 percent) as well as some areas of high fishing that resulted in high LEIs (more than 50 percent or even more than 75 percent) LEIs. In the AI, GOA, and EBS slope, substantial LEIs were primarily concentrated into many small, discrete pockets. On the EBS shelf, there were two larger areas where high LEIs were concentrated: (1) an area of sand/mud habitat between Bristol Bay and the Pribilof Islands, and (2) an area of sand habitat north of Unimak Island and Unimak Pass mostly inside of the 100-m contour.

Some of the patterns in fishing effects can be related to areas closed to bottom trawl fishing. In the GOA, no bottom trawling is allowed east of 140ºE longitude and fishing effects are light there. Bottom trawling has been substantially restricted within specified radii (10 and 20 nm) of Steller sea lion rookeries and haulouts. The effects of these actions on LEI values are most clearly seen in the AI, where high LEI values are concentrated in small patches where the narrow shelf does not intersect these closures. In the EBS, two large areas, around the Pribilof Islands and in and adjacent to Bristol Bay, both mostly in sand substrates, are closed to bottom trawling to protect red king crab habitat. These closures concentrate fishing in the southern part of the EBS into the remaining sand, sand/mud, and slope habitats, which likely increases the predicted LEI in those areas.

Aggregate LEIs for each of the habitats are shown in Table B.2-8. As discussed above, prey declined less than biostructure due to lower sensitivity and faster recovery rates. No prey feature was reduced by more than 3.5 percent (BS slope habitat). Biological structure features had LEIs between 7 and 9 percent in the hard substrate habitats where recovery rates were slow. LEIs above 10 percent were indicated for the biological structure of the sand/mud and slope habitats of the EBS where fishing effort is concentrated and recovery rates are moderately slow.

Because of uncertainties in key input parameters, some evaluation was needed of how widely the resulting estimates might vary. In addition to the LEIs cited above, which were generated with median or central estimates for each input parameter (referred to below as Central LEIs), LEI was estimated for both large and small values of sensitivity and recovery. High estimates of sensitivity were combined with low recovery rates to provide an “upper LEI” and low estimates of sensitivity were combined with high recovery rates producing a “lower LEI.” Lower LEIs for the habitat features (except for coral, which is discussed below) ranged from 8 to 50 percent of the original median estimates. Infaunal and epifaunal prey lower LEIs were all at or below 0.5 percent proportional reduction habitat, those for non-living structure were below 2 percent, and those for living structure were below 4 percent. The corresponding upper LEIs ranged from 1.5 to 3 times the original median estimate. The largest upper LEI values for infauna and epifauna prey were for the EBS sand/mud and slope habitats and ranged from 3.5 to 7 percent, with all other upper LEIs below 2 percent. Non-living structure upper LEIs were greatest on the GOA hard substrates, the AI shallow water habitat and the EBS slope, ranging from 7 to 14 percent, with all other upper LEIs below 4 percent. In six habitats, the three GOA hard substrates, the AI shallow water habitats and the EBS sand/mud and slope habitats, the upper LEI exceeded 10 percent, with the highest value (21 percent) on the GOA slope.

The analysis also calculated the proportion of each LEI attributable to each fishery. Fishery-specific LEI values for the habitat/feature combinations with the highest overall LEIs (all involving living structure) in each region are presented in Table B.2-9. While the pollock pelagic trawl fishery was the highest single component (4.6 percent) of the total effects on living structure in the EBS sand/mud habitat, the combined effects of the bottom trawl fisheries made up all of the remaining 6.3 percent (total LEI 10.9 percent). This was not true for living structure on the EBS slope, where nearly all (7.2 percent out of a total 10.9 percent) of the LEI was due to the pollock pelagic trawl fishery. Living structure on hard bottom substrates of the GOA slope was affected by bottom trawling for both deepwater flatfish and rockfish. While the LEIs of these two fisheries were nearly equal, it is likely that much more of the rockfish effort occurred on hard substrates as compared with trawling for deepwater flatfish. (Because the spatial distribution of hard and soft substrate was unknown, such differences are not explicitly accounted for in the fishing effects analysis.) Therefore, most of the effects on this feature were attributed to the rockfish trawl fishery. In the shallow, hard substrate habitat of the AI, most of the effects (4.2 percent out of a total 7.3 percent) on living structure were attributable to the trawl fishery for Pacific cod. The remainder was attributed to Atka mackerel trawling at 2.5 percent. Living structure was the only habitat feature in which the effect of a passive gear fishery, longlining for Pacific cod, had an LEI above 0.1 percent. This fishery accounts for the consistent light blue (less than 1 percent LEI) coverage in Figure B.2-4 of many shallow areas of the AI not open to trawling.

Results for ultra-slow recovering structures, represented by hard corals, were different from those of other living structure in several ways. Corals had the highest LEI values of the fishing effects analyses. Because the very slow recovery rate of these organisms results in very high (more than 75 percent LEI) eventual effects with more than the most minimal amount of trawl fishing (annual trawl effort less than one tenth the area of the block), the distribution of high LEI values directly reflect the distribution of blocks subject to more than minimal trawl effort (Figure B.2-6). The LEI values by habitat range from 6 to 20 percent with the highest values in the shallow AI and the Gulf slope. These results mostly reflect the proportion of blocks in each habitat type subject to more than minimal trawl effort. Even though fairly wide ranges of both sensitivity and recovery rates were used for the upper and lower LEI estimates for coral, the range between upper and lower was not as wide as for the other living structure organisms, ranging from plus 40 percent to -33 percent of the central value.

This analysis combined available information to assess effects of Alaska fisheries on marine fish habitat. It estimated the effects (as measured by LEIs) of fisheries on habitat features that may be used by fish for spawning, breeding, feeding, or growth to maturity. These LEIs represent the proportion of feature abundances (relative to an unfished state) remaining if recent fishing patterns were continued indefinitely (to equilibrium). Therefore, all LEIs represent effects that are not limited in duration and satisfy the EFH regulation's definition of "not temporary." The magnitude and distribution of feature LEIs can thus be compared with the distribution of the use of that feature by fish species to assess whether the effects are "more than minimal" relative to that species' EFH (Section B.3). Effects meeting this second element would necessarily meet both elements (more than minimal and not temporary) due to the nature of the LEI estimates.

B.2.6 Effects on Habitat Features—Summary

Across broad habitats, LEIs were generally small (largest central LEI 11 percent). Living structure was the most vulnerable of the features, followed by non-living structure. Both infaunal and epifaunal prey were more resilient, with a maximum central LEI for a habitat of 3.5 percent.

As fishing efforts were the only data available on a small spatial scale, the details of the LEI maps represent distributions of fishing effort, weighted on a much broader scale for habitat vulnerability characteristics. Therefore, they only represent the potential for reduction of whatever habitat features may be present in each block, without discriminating differences in habitat function between blocks.

In particular locations, certain LEIs (particularly for living structure) were quite substantial. The area with the largest overall LEIs was a patch of sand habitat north of Unimak Island and Unimak Pass, where biological structure LEIs for most of the 5×5 km blocks were greater than 75 percent. A larger area in the sand/mud habitat of the EBS between Bristol Bay and the Pribilof Islands had living structure LEIs mostly between 25 and 75 percent with a few above 75 percent. Areas with larger LEIs on the EBS slope and in the GOA and AI were much smaller and more scattered. The intensity of effects in these patches is likely affected by redistribution of fishing effort from existing fishing closures. The Unimak patch is the only sand habitat remaining open to trawling in the southern BS shelf after closures to protect red king crab habitat. The other EBS patch is directly between the two areas affected by those closures.

Hard corals have ultra-slow recovery rates, which make them very vulnerable to long-term effects from fishing. LEI calculations indicated that wherever these features encounter trawling effort above one-tenth of a block's area per year, they had LEIs above 75 percent. The spatial distribution of coral LEIs (Figure B.2-6) essentially identified all trawled areas. As described above, LEIs are estimated for all areas regardless of the abundance, or even the presence of a habitat feature. Because hard corals have particular habitat requirements, including hard substrate and significant currents, a large proportion of the blocks in Figure B.2-6 with high coral LEIs do not include suitable habitat for hard corals; hence no coral reduction actually occurs. Therefore, consideration of coral LEIs focuses on the Aleutians and the Gulf of Alaska slope, areas of known hard coral abundance.

Coral LEIs were also particularly subject to biases (described in Section B.2.2) due to interactions between the small scale patchiness of the presence of these organisms with the patchiness of fishing effort. In hard-bottom areas, fishing location must consider both seeking higher abundances of fish and avoiding structures (including rocks, rough bottom, and coral) that may damage fishing gear. This tends to move fishing effort toward smoother seafloors and away from some coral habitats. Adding a seafloor constraint also concentrates fishing into known areas of fishable bottom, increasing overlap between tows. To the extent that fishing effort tends to overlap previous tows more than random placement would predict, LEIs overestimate actual effects because trawling encounters less undamaged structure. Therefore, the raw coral LEIs should not be taken at face value, and the above effects should be considered in their application.

In addition to the primary objective of assessing effects of fishing on habitat, another important function of this analysis was to identify weaknesses in the information base on which such an assessment must rely. Many of the parameters used in this analysis are speculative and only indirectly supported. These areas should be developed with further, or in some cases, initial, research. Areas of particular need include sensitivity of Alaska habitat species to fishing gear used in Alaska, the recovery rates of biological structure-forming organisms, the proportion and distribution of pelagic trawl effort in contact with the seafloor, the definition and characterization of habitat types and features relevant to managed species, the contact of longlines and pots with the seafloor and their effects, and methods for reducing the effects of fishing gears on habitats. Finally, a vital information gap is establishing linkages between changes in the availability of habitat features and the success of the life-history processes of fish species, and the subsequent effects on population abundances and structures.

Determining whether reductions of EFH are more than minimal and not temporary is conditioned on the premise that the habitat features being measured in some way affect the ability of managed species to feed, reproduce, and grow to maturity. Also considered is the extent to which a reduction in habitat limits a species ability to support a fishery or participate in environmental linkages. Strong and specific dependencies on habitat would be necessary for the reductions in habitat features noted here to result in fish population reductions of similar magnitudes. Results of this analysis show reduction proportions well below the annual harvest rate for most of the managed species. On the other hand, much more specific knowledge of habitat dependencies would be needed to detect species-specific limitations that could create a population bottleneck. The following section will, to the extent possible with available information, assess the effects of the estimated reductions in habitat on the populations of managed species.

While this analysis provides a tool for bringing disparate sources of information to bear on the evaluation of fishing effects on EFH, numerous limitations arose of which users should remain mindful. Both the developing state of the model and the limited quality of available data to estimate input parameters prevent this from providing a clear view of habitat effects. While output detail may provide an illusion of precision, the results are actually subject to considerable uncertainty. It is merely the best tool currently available for this assessment, not a definitive predictor.

B.3 Evaluation of Effects on Managed Species

The principal application of this document is to evaluate whether the fisheries, as they are currently conducted off of Alaska, will affect habitat that is essential to the welfare of the managed fish populations in a way that is more than minimal and not temporary. The previous statement describes the standard set in the EFH regulations which, if met, requires Councils to act to minimize such effects. The above analysis has identified changes to habitat features that are not expected to be temporary. The habitat features were selected as those which a) can be affected by fishing, and b) may be important to fish in spawning, breeding, feeding, and growth to maturity. This section evaluates the extent that these changes relate to the EFH of each managed species and whether they constitute an effect to EFH that is more than minimal.

Two conclusions are necessary for this evaluation: (1) the definition of EFH draws a distinction between the amount of habitat necessary for a species to "support a sustainable fishery and the managed species' contribution to a healthy ecosystem" (50 CFR 600.10) and all habitat features used by any individuals of a species; (2) this distinction applies to both the designation of EFH and the evaluation of fishing effects on EFH. If these conclusions are valid, the "more than minimal" standard relates to impacts that potentially affect the ability of the species to fulfill its fishery and ecosystem roles, not just impacts on a local scale. The forgoing analysis has indicated substantial effects to some habitat features in some locations, many of which are likely within the spatial boundaries of the EFH of a species that may use them in a life-history function. They may also, however, have no potential for affecting the welfare of that species (a term that we will use to represent "the ability of a species to support a sustainable fishery and its role in a healthy ecosystem").

B.3.1 Evaluation Methods

The following evaluation assesses whether the fisheries, as they are currently conducted off Alaska, are affecting habitat that is essential to the welfare of the species in question in a way that is more than minimal and not temporary. The following resources were used:

1. The results of the effects of fishing analysis (Section B.2)
2. Literature and other sources of knowledge regarding what each species requires to accomplish spawning, breeding, feeding and growth to maturity
3. Knowledge of the responses of the recruitment, biomass, and growth of these species during periods with similar fishing intensities
4. The knowledge and professional judgement of scientists that manage and study these species

For each species, a knowledgeable scientist was designated to perform the evaluation. The initial step was identification of any known linkages between the life stages of the species and the habitat features in each habitat used in the effects-of-fishing analysis. These linkages are summarized in Table B.3-1. Scientists then reviewed these linkages and other knowledge to describe the known habitat connections between the species and/or species group and the three life history processes of spawning/breeding (combined), feeding of adults, and growth to maturity (including feeding, growth, and survival before maturity). The texts of these reviews, labeled Habitat Connections, are found in Sections B.3.3 to B.3.5.

The scientists were then asked to evaluate the following question: *Are the fisheries, as they are currently conducted off Alaska, affecting habitat that is essential to the welfare of the species in question? Also, describe specifically in what ways and to what extent?* These evaluations were separated into three issues, corresponding to the above three life-history processes spawning/ breeding, feeding of adults, and growth to maturity. The criteria for these issues are described in Table B.3-2.

Because EFH comprises the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem, a consistent, existing benchmark was useful to represent these concepts in EFH evaluations. The ability of the species to maintain populations above Minimum Stock Size Threshold (MSST) was selected to represent the ability of the species to support a sustainable fishery. In the National Standard Guidelines to the Magnuson-Stevens Act, sustainability is defined relative to the MSST, where stocks below the MSST are considered sufficiently small as to require an appropriate rate of rebuilding. This concept of sustainability was used here to maintain consistency with the National Standard Guidelines. No similar benchmark was available for the role of each species in a healthy ecosystem. However, population levels sufficient to support a fishery do ensure at least a significant presence in the ecosystem. Therefore, unless the evaluating scientists knew of ecosystem functions of the species that required a higher threshold level, they were instructed to use ability to stay at or above MSST as proxy for that criterion as well. For species where MSST could not be estimated with available data (recruitment estimates not available), assessing effects on EFH had to rely on other proxies or ratings of "unknown" were necessary.

Two principal considerations were available to assess whether effects on EFH were more than minimal and not temporary. One used the LEIs from the effects-of-fishing analysis and the linkages identified in the habitat connections exercise. Considering the importance of each habitat feature to species welfare and the distribution of persistent effects (LEI) on those features relative to their use by the species, evaluators assessed whether the expected effects on species welfare were more than minimal. Evaluators considered which life history functions could be affected by changes in available habitat, the role of those functions in species welfare, and the spatial overlap of habitat use with the estimated fishing effects. For many species, limited information is available for one or all of these factors. Therefore, the professional knowledge and judgement of the evaluator was important. Because LEIs are inherently "not temporary," any such effects assessed as "more than minimal" met both elements of the test for effects requiring Council action to minimize.

To aid evaluations, LEI charts and all three LEI values (lower, central, upper) for each habitat were provided. The LEI charts provided effect information at the finest feasible scale, allowing evaluators to focus on any specific sites considered important to their species. To assist evaluators in considering the cumulative effects to habitats across the distribution of each species, LEIs were aggregated for the intersections of each habitat and two geographical EFH areas for each species, the general distribution and the known concentration. Derivation and charts of these areas are in Section 2.3.1. This process also provided the proportion of each species EFH within each habitat. The resulting LEIs and habitat proportions are displayed in Table B.3.3.

The other consideration was an assessment of the stock condition of each species. For at least 30 years, fishing effort and presumably its habitat effects have been at similar or higher levels than the recent levels evaluated here. The condition of fish populations through this period is, therefore, one indicator of their response to all effects of fishing, including those on EFH. The EFH of species that maintained a favorable stock condition through this period, while supporting a fishery, was considered resistant to habitat effects caused by this level of fishing. While poor stock performance could have resulted from a number of factors, including the direct effects of fishing and environmental change, consistently favorable stock conditions indicate that none of these, including fishing's effect on habitat, has jeopardized stock productivity. Again, the knowledge and expertise of each evaluator were required to assess the effect of any special circumstances for their species that made this a stronger or weaker form of evidence.

For fish stocks where information was available to estimate recruitment, recruitments from the late 1970s to the present were used in assessing stock condition relative to MSST. These estimated recruitments, as well as other stock characteristics such as growth rates, represent a range of recent history when impacts to the stock from fishing practices would have been expected. As part of the Draft Groundfish Programmatic SEIS (NMFS 2003), 10-year projections were made to assess whether the stocks would be likely to fall below their MSST level under the status quo harvesting policy, as well as a broad range of alternative policies. These projections combine the current stock status and historical distributions of population parameters, both of which reflect any effects of historic levels of fishing that have been similar to or greater than current levels. Their resulting analysis of stock status relative to MSST was used by evaluators as an indicator of effects of recent fishing intensities on managed species and their EFH. Evaluators were knowledgeable of any peculiarities in their species' history that would make this indicator more or less relevant. In the absence of other indicators, a positive MSST analysis justified a rating of minimal or temporary effects. It was not possible to use this indicator for species where MSST cannot be estimated with available data (recruitment estimates not available).

Either of the two lines of consideration (habitat connections or MSST analysis) could be overcome by the other, and the authors were expected to weigh the specific evidence for any consequences of habitat effects. Definitive proof of a population level effect was not required to rate effects as more than minimal and not temporary. A strong stock history could be overcome by a clear connection between LEIs and species requirements. Given the current state of knowledge, uncertainties were expected, and evaluators indicated where these might be important or raised concerns.

B.3.2 Effects of Fishing on Essential Fish Habitat of Salmon, Scallops, and Crab

The following evaluations were made to answer the question: *"Are the fisheries, as they are currently conducted off Alaska, affecting habitat that is essential to the welfare of the species in question? If so, describe specifically in what ways and to what extent?"*

B.3.2.1 Salmon Species

Habitat Connections

There are five species of Pacific salmon (chinook, chum, pink, coho, sockeye) managed under the Alaska salmon FMP. Because all of these species use similar types of habitat, including habitats where fishing activities may occur, the evaluation of fishing effects on EFH were considered for all species together.

Spawning/Breeding—Salmon spawn and deposit their eggs in gravel areas of freshwater rivers and streams. Successful spawning is dependent upon the numbers of spawners, available habitat for spawning and nursery areas, and environmental conditions. Impacts to spawning and breeding of salmon occur when these habitat areas are disturbed, spawning biomass is reduced, or spawners are unable to reach suitable spawning areas.

Feeding—Once salmon smolts begin to enter the ocean, they feed on copepods. As they get larger, they add squid, juvenile herring, smelt, and other forage fish and invertebrate species to their diets. Salmon smolts use the nearshore area after entering the ocean, moving offshore as they get older, using pelagic habitats when at sea.

Growth to Maturity—Salmon feed throughout the open ocean of the North Pacific for up to 6 years (depending upon species) before maturing and returning to their natal rivers to spawn. Growth and mortality of juveniles depend on food availability, predation, bycatch in fisheries, and environmental conditions.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

No commercial fisheries in Alaska are thought to adversely affect salmon spawning habitat given almost no effort (except recreational and subsistence fisheries) in freshwater spawning and rearing areas. Thus, the effects of the fisheries on spawning of salmon are considered minimal and temporary in nature.

Fisheries are considered not to have any impact on freshwater or pelagic habitats used by juvenile salmon. However, fisheries do catch some species eaten by piscivorus species of salmon in the ocean, including squid, capelin, and juvenile herring. Currently, the catch of these prey species is very small relative to overall population size of these species, so fishing activities are considered to have minimal and temporary effects on feeding of all salmon species.

As stated above, fisheries are considered to have minimal effects on prey availability of salmon, including juveniles. Fisheries impacts on juvenile salmon at sea are due to incidental catches in groundfish fisheries. Bycatch in groundfish fisheries is almost non-existent for pink salmon, coho salmon, and sockeye salmon, but does occur in measurable numbers for chum salmon and chinook salmon taken in trawl fisheries, particularly the pollock trawl fisheries (Witherell et al. 2002). The bycatch amounts are considered to be a small proportion of the stocks and do not cause a substantial impact on salmon populations (Witherell et al. 2002). Thus, fishing activities are considered to have minimal and temporary effects on growth to maturity of salmon.

Fishing activities are considered to have overall minimal and temporary effects on the EFH for all salmon species. Fishing activities only interact with salmon habitat to any degree in the ocean habitats, and the concerns about these interactions center on effects on prey availability and bycatch. Note that prey of salmon (from copepods up to squid and forage fish) are not subject to directed fisheries removals, and bycatch is not a significant factor in total mortality. Professional judgement led to the conclusion that fisheries do not adversely affect the EFH of salmon species.

B.3.2.2 Weathervane Scallops

Habitat Connections

Weathervane scallops are found from shallow intertidal waters to depths of 300 m, but abundance tends to be greatest between depths of 40 to 130 m on beds of mud, clay, sand, and gravel (Hennick 1973, Turk 2000). Scallop beds tend to be elongated along the direction of current flow. A combination of large-scale processes (overall spawning population size and oceanographic conditions) and small-scale processes (site suitability for settlement) influence the recruitment of scallops to beds.

Spawning/Breeding—Successful scallop recruitment depends upon high egg-fertilization rate, transport of spat to nursery areas, environmental conditions, and survival to the adult stage. Scallop gametes are broadcast into the water and rely on currents to mix sperm and eggs. If males and females are not close together, the dilution of sperm can limit fertilization. Thus, spatial distribution is thought to be a critical component of the spawning/breeding success of scallops (Stokesbury 2000, ADF&G 2000). Indicators of potential effects on spatial distribution are changes in population biomass and fishing mortality.

Feeding—Scallops are filter feeders. Successful feeding of scallops depends upon the concentration and quality of suspended food particles, particularly phytoplankton. Prey availability is dependent upon localized plankton blooms. Fishing activity can impact feeding of scallops through introduction of particles low in nutrient quality or organic content, thus diluting the naturally occurring nutritional particles (MacDonald 2000). More fishing activity by trawl or dredge gear could potentially introduce additional inorganic particulate matter that could negatively affect scallop feeding success, or conversely, introduce organic matter that could be beneficial to scallops.

Growth to Maturity—Growth to maturity is measured in terms of survival to maturity (which occurs at sizes smaller than commercially harvested). The consequences of fishing activities on scallop survival depend upon habitat alteration and gear-induced damage and mortality (Grant 2000). The effects of habitat alternation may be mostly dependent upon sediment resuspension and the potential for siltation, which would increase mortality.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	U (Unknown effect)
Growth to maturity	MT (Minimal or temporary effect)

Because scallops have limited mobility, scallop settlement generally occurs on substrates and in locations where adults are already found (Turk 2000). Thus, the nursery areas are the same areas occupied by adults. These are also the areas where the directed scallop fisheries occur. However, there is no evidence that scallop recruitment has decreased with the current level of scallop fishing effort.

The overlap of fisheries with scallop EFH occurs primarily with the scallop fishery. The overall footprint (area effected annually) of the scallop fishery was small (149 square nm), equating to about 0.1 percent of the total available amount of those habitat types (sand, mud, and gravel) (Witherell 2002). Although the effects of scallop dredge gear on the bottom are thought to be higher than other gear types, the fishery occurs in areas and habitat types that have relatively fast recovery rates. Thus, the effects of the fishery are concentrated in a relatively small proportion of benthic habitats. The effects on spawning and breeding of scallops are considered minimal and temporary in nature.

Sediment resuspension by dredges can have positive or negative effects on scallop feeding. The current fishing effort intensity of the Alaska scallop fishery does not appear to affect scallop growth, so one may surmise that feeding is not disturbed. However, there is not enough information to evaluate this issue.

The weathervane scallop resource is considered to be at sustainable biomass levels and has maintained relatively high recruitment in most areas over the past 10 years (Jeff Barnhart, ADF&G personal communication). This species does not depend upon any habitat feature vulnerable to fishing activities. Based on the overlap of fisheries with juvenile and adult scallop stock distribution, there appears to be minimal effects on the Weathervane scallop habitat.

B.3.2.3 Red King Crab

Spawning/Breeding—Spawning and breeding success of crab species depends upon high egg-fertilization rate, successful transport of pelagic larvae to nursery areas, good environmental conditions, and survival to the adult stage. Egg fertilization success depends upon the size and number of mature male crabs (and hence the amount of sperm) available. The eggs are attached to the underside of females and carried for nearly a year prior to hatching. Transport of larvae depends upon environmental conditions, and survival depends upon the quantity and quality of nursery habitat and the presence of predators.

Settlement and nursery areas are important component of spawning success for crab species. For red king crabs, selection of benthic habitat by glaucothoe appears to be an important mechanism leading to increased probability of larvae settling on an appropriate substrate. Such substrates appear to be largely rock or cobble bottoms, mussel beds or other areas with a variety of epifauna such as hydroids or epiflora (i.e., kelp hold fasts).

The overlap of groundfish trawl effort with mature female red king crabs is very limited. The existing trawl closure areas encompass nearly the entire stock. The overlap with males does occur to some extent outside of trawl closure areas. However, the vast majority of adult males occur within the trawl closure areas.

Feeding—From settling larvae to senescence, crabs dwell on the bottom and are dependent upon benthic feeding, the importance of habitat quality to crab diet seems intuitive but is not quantified for benthic life stages. Changes in diet due to habitat disturbance may impact crab survival and production, however, the effects of these changes will be difficult to assess given the limited information on feeding requirements of crab species.

Growth to Maturity—Early stage red king crabs seek out biological cover in which to hide. Survival at this stage depends upon availability of cover. After they reach a size exceeding 25 mm carapace length, red king crabs form pods, which consist of similar sized crabs of both sexes, and may contain hundreds to thousands of crabs. Pods of juvenile crabs form during the daytime, but disperse at night for feeding. The overlap of groundfish trawl effort with nursery areas for red king crabs is very limited. The existing trawl closure areas encompass nearly the entire stock.

Habitat Connections, Evaluation of Effects

Issue	**Evaluation**
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	U (Unknown effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Summary of Effects (MT)—Fishing activities are considered to have overall minimal and temporary effects on the EFH for red king crab. Fishing activities thought to have adverse consequences to red king crab stocks have previously been mitigated by establishment of trawl closure areas. Given the very small overlap and fishing intensity in areas with red king crab of all life stages, professional judgement led to the conclusion that fisheries do not adversely affect the EFH of red king crab.

B.3.2.4 Blue King Crab

Habitat Connections, Evaluation of Effects

Issue	**Evaluation**
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	U (Unknown effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Spawning/Breeding—Spawning and breeding success of crab species depends upon high egg-fertilization rate, successful transport of pelagic larvae to nursery areas, and survival to the adult stage. Egg fertilization success depends upon the size and number of mature male crabs (and hence the amount of sperm) available. The eggs are attached to the underside of females and carried for many months prior to hatching. Transport of larvae depends upon environmental conditions, and survival depends upon the quantity and quality of nursery habitat and the presence of predators.

Settlement and nursery areas are important components of spawning success for crab species. For king crabs, selection of benthic habitat by glaucothoe appears to be an important mechanism leading to increased probability of larvae settling on an appropriate substrate. Such substrates appear to be largely rock or cobble bottoms, mussel beds or other areas with a variety of epifauna such as hydroids or epiflora (i.e., kelp hold fasts).

The overlap of groundfish trawl effort with mature female blue king crabs is very limited. The existing trawl closure area in the Pribilof Islands encompasses nearly the entire Pribilof Islands stock, and there is virtually no overlap of trawl fisheries with the St. Matthew blue king crab stock.

Feeding—From settling larvae to senescence, crabs dwell on the bottom and are dependent upon benthic feeding, the importance of habitat quality to crab diet seems intuitive but is not quantified for benthic life stages. Changes is diet due to habitat disturbance may impact crab survival and production, however, the effects of these changes will be difficult to assess given the limited information on feeding requirements of crab species.

Growth to Maturity—Early stage blue king crabs seek out biological structure in which to hide. Survival at this stage depends upon availability of cover. The Pribilof Islands habitat conservation area was established in 1995 to eliminate potential effects of trawling on this habitat feature.

Summary of Effects (MT)—Fishing activities are considered to have overall minimal and temporary effects on the EFH for Blue king crab. Although both the Pribilof Islands stock and St. Matthew stock of blue king crabs are considered to be below MSST, habitat loss or degradation by fishing activities is not thought to have played any role in the decline of these stocks. For the Pribilof Islands blue king crab any fishing activities thought to have adverse consequences have previously been mitigated by establishment of the Pribilof Islands trawl closure area. For St. Matthew blue king crab, there has never been a groundfish bottom trawl fishery in the area. Given the current very small overlap and fishing intensity in areas with blue king crab of all life stages, professional judgement led to the conclusion that fisheries do not currently adversely affect the EFH of blue king crab.

B.3.2.5 Golden King Crab

Habitat Connections, Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Spawning/Breeding—Spawning and breeding requirements for golden king crab are unknown. It is likely that settlement and nursery areas are important component of spawning success. For other species of king crabs, selection of benthic habitat by glaucothoe appears to be an important mechanism leading to increased probability of larvae settling on an appropriate substrate.

The overlap of groundfish trawl effort with mature female golden king crabs is very limited. Trawl fishing intensity does overlap to some extent with crab distribution on the EBS slope, but not in the AI slope area.

Feeding—From settling larvae to senescence, crabs dwell on the bottom and are dependent upon benthic feeding, the importance of habitat quality to crab diet seems intuitive but is not quantified for benthic life stages. Changes is diet due to habitat disturbance and alternative may impact crab survival and production, however, the effects of these changes will be difficult to assess given the limited information on feeding requirements of crab species.

Growth to Maturity—Early stage king crabs may seek out biological structure in which to hide. It is not known how the fisheries affect habitat used by juvenile golden king crabs.

Summary of Effects—Fishing activities are considered to have overall minimal and temporary effects on the EFH for golden king crab. Groundfish trawl fishing in the EBS slope is of some concern, however, any effects are thought to be minimal. Professional judgement led to the conclusion that fisheries do not adversely affect the EFH of golden king crab.

B.3.2.6 Scarlet King Crab

Habitat Connections, Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Spawning/Breeding—The spawning and breeding and habitat requirements for scarlet king crab are unknown. Nevertheless, the overlap of groundfish trawl effort with mature female crabs is likely very limited, given the deep water nature of this species. There is virtually no directed pot fishery for this species. A few landings were made in 1995 (2,600 lbs) and 1996.

Feeding—Nothing is known about the feeding requirements for this species.

Growth to Maturity—Factors affecting growth and survival of this species are not known. Almost none are taken as bycatch in groundfish or crab fisheries.

Summary of Effects—Fishing activities are considered to have overall minimal and temporary effects on the EFH for scarlet king crab. This is a deepwater species with almost no overlap with commercial fisheries, so habitat effects are unlikely. Professional judgement led to the conclusion that fisheries are unlikely to adversely affect the EFH of scarlet king crab.

B.3.2.7 Tanner Crab

Habitat Connections, Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Spawning/Breeding—Spawning and breeding success of crab species depends upon high egg-fertilization rate, successful transport of pelagic larvae to nursery areas, and survival to the adult stage. Egg fertilization success depends upon the size and number of mature male crabs (and hence the amount of sperm) available. The eggs are attached to the underside of females and carried for nearly a year prior to hatching. Transport of larvae depends upon environmental conditions. Tanner crabs settle on mud habitats.

Fishing activities do occur in the same areas as mature female Tanner crabs. The overlap of groundfish trawl effort with mature female crabs does occur to some degree. The overlap of the crab fishery with available benthic habitat is very small, and likely has no effect on mature female Tanner crab habitat.

Feeding—The effects of fishing activities on Tanner crab feeding activities is minimal. Tanner crabs feed on an extensive variety of benthic organisms including bivalves, brittle stars, crustaceans (including other Snow crabs), polychaetes and other worms, gastropods, and fish. Relative to the distribution of fisheries and the intensity of fisheries effects, only a small reduction of the infauna and epifauna prey occurs on mud habitats.

Growth to Maturity—No studies indicate a direct dependance of juvenile Tanner crabs on any vulnerable habitat feature. They are believed to settle and grow on mud habitat, which was the least affected habitat in the EBS.

Summary of Effects—Fishing activities are considered to have overall minimal and temporary effects on the EFH for Tanner crabs.

B.3.2.8 Snow Crab

Habitat Connections, Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Spawning/Breeding—Spawning and breeding success of crab species depends upon high egg-fertilization rate, transport of pelagic larvae to nursery areas, and survival to the adult stage. Egg fertilization success depends upon the size and number of mature male crabs (and hence the amount of sperm) available. The eggs are attached to the underside of females and carried for nearly a year prior to hatching. Transport of larvae depends upon environmental conditions. Snow crabs settle on mud habitats.

Fishing activities do occur in the same areas as mature female snow crabs. The overlap of groundfish trawl effort with mature female crabs does occur to some degree. The overlap of the crab fishery with available benthic habitat is very small and likely to have no effect on mature female snow crab habitat.

Feeding—Snow crabs feed on an extensive variety of benthic organisms including bivalves, brittle stars, crustaceans (including other snow crabs), polychaetes and other worms, gastropods, and fish. Considering the distribution of fisheries and the intensity of fisheries effects, only a small reduction in the infauna and epifauna prey is projected for mud habitats. Thus, there are minimal effects on feeding of snow crabs.

Growth to Maturity—No studies indicate a direct dependance of juvenile snow crabs on any vulnerable habitat feature. They are believed to settle and grow on mud habitats, which was the least affected habitat in the EBS.

Summary of Effects—Fishing effects on EFH are considered to have overall minimal and temporary effects on the EFH for snow crabs.

B.3.2.9 Deepwater Tanner Crabs

Habitat Connections, Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Spawning/Breeding (MT)—The spawning and breeding and habitat requirements for grooved Tanner crab and triangle crab are unknown. Nevertheless, the overlap of groundfish trawl effort with mature female crabs is likely very limited, given the deep water nature of these species. There is virtually no directed pot fishery for this species in recent years. Only a few landings of deepwater Tanner crab have been made in the EBS: 49,000 lbs of triangle crab in 1995 and minor confidential landings in 1996 and 2000 and 106,000 lbs of grooved crab in 1996 and minor confidential landings in 2000. Also, 145,000 lbs of grooved crabs were harvested in the AI in 1995.

Feeding—Nothing is known about the feeding requirements for these species.

Growth to Maturity—Factors affecting growth and survival of this species are not known. Almost none are taken as bycatch in groundfish or crab fisheries.

Summary of Effects—Fishing activities are considered to have overall minimal and temporary effects on the EFH for deepwater Tanner crabs. These are deepwater species with almost no overlap with commercial fisheries, so habitat effects are unlikely. Professional judgement led to the conclusion that fisheries are unlikely to adversely affect the EFH of deepwater Tanner crabs.

B.3.3 Effects of Fishing on Essential Fish Habitat of Groundfish Species

The following evaluations were made to answer the question: *"Are the fisheries, as they are currently conducted off Alaska, affecting habitat that is essential to the welfare of the species in question? If so, describe specifically in what ways and to what extent?"*

B.3.3.1 Walleye Pollock (BSAI & GOA)

Habitat Connections

Spawning/Breeding
Peak pollock spawning occurs on the southeastern BS and eastern AI along the outer continental shelf around mid-March. North of the Pribilof Islands spawning occurs later (April-May) in smaller spawning aggregations. The pollock of the Aleutian Basin spawn in deep water and appear to spawn slightly earlier, late February-early March. In the GOA, peak spawning occurs in late March in Shelikof Strait. Peak spawning in the Shumagin area occurs 2 to 3 weeks earlier than in Shelikof Strait.

Spawning occurs in the pelagic zone and egg development occurs throughout the water column (70 m to 80 m in the EBS shelf, 150 to 200 m in Shelikof Strait). Rate of development is dependent upon water temperature. In the EBS, eggs take about 17 to 20 days to develop at 4ºC in the Bogoslof area and 25.5 days at 2ºC on the continental shelf. In the GOA, development takes approximately 2 weeks at ambient temperature (5ºC). Larvae are also distributed in the upper water column. In the EBS the larval period lasts approximately 60 days. The larvae eat progressively larger naupliar stages of copepods as they grow, and then small euphausiids as they approach transformation to juveniles (~25 mm standard length). In the GOA, larvae are distributed in the upper 40 m of the water column and the diet is similar to EBS larvae. FOCI survey data indicate larval pollock may use the stratified warmer upper waters of the mid-shelf to avoid predation by adult pollock, which reside in the colder bottom water. See Section 3.2.1.2.1 for further discussion and references.

Feeding
The adults feed mainly on pelagic euphasiids followed by calanoid copepods, which are not one of the affected habitat features. See Section 3.2.1.2.1 for further discussion and references.

Growth to Maturity
Pollock larvae are pelagic. Juveniles (in particular, 1-year olds) are common near the bottom based on the summer bottom trawl surveys. Whether this association is due to habitat shelter (predator avoidance), food availability, or simply due to external forces (e.g., temperature preference, advection, etc.) is unknown. Adults are semipelagic. Adults are demersal at times and are associated with a variety of habitats. They exhibit strong diel vertical migrations with nightly movements away from the bottom up into the water column. See Section 3.2.1.2.1 for further discussion and references.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Pollock eggs, older juveniles, and adults are not primarily associated with benthic habitats. Therefore, the impact of reducing benthic habitat features is likely to be minor (Table B.3-1). Age-one juveniles are commonly found associated with the bottom during summer trawl surveys and similar patterns have been observed in the GOA. This pattern could be associated with habitat features that could be affected by trawling. However, the cause for this pattern is poorly understood. As determined in the Draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the walleye pollock stocks to maintain themselves at or above their respective MSSTs. Therefore, the effects of the reductions in habitat features on spawning/breeding and growth to maturity are either minimal or temporary in terms of the walleye pollock stocks' abilities to maintain themselves at or above MSST. Therefore the ratings for the effects of spawning/breeding and growth to maturity for BSAI/GOA pollock are "MT." The adults feed mainly on pelagic euphasiids followed by calanoid copepods. Neither of these are part of the affected habitat features, therefore it is assumed that the reductions of non-living structure in areas where pollock live would not have an impact (no effect), and the rating for feeding is also "MT."

B.3.3.2 Pacific Cod (BSAI & GOA)

Habitat Connections

Spawning/Breeding
Spawning takes place in the sublittoral-bathyal zone (40 to 290 m) near bottom. Eggs sink to the bottom after fertilization, and are somewhat adhesive. Optimal temperature for incubation is 3 to 6° C, optimal salinity is 13 to 23 parts per thousand (ppt), and optimal oxygen concentration is from 2 to 3 parts per million (ppm) to saturation. Little is known about the optimal substrate type for egg incubation. See Sections 3.2.1.1.2 and 3.2.1.2.2 for further discussion and references.

Feeding
Pacific cod are omnivorous. In terms of percent occurrence, the most important items in the diet of Pacific cod in the BSAI and GOA are polychaetes, amphipods, and crangonid shrimp. In terms of numbers of individual organisms consumed, the most important dietary items are euphausiids, miscellaneous fishes, and amphipods. In terms of weight of organisms consumed, the most important dietary items are Walleye pollock, fishery discards, and yellowfin sole. Small Pacific cod feed mostly on invertebrates, while large Pacific cod are mainly piscivorous. See Sections 3.2.1.1.2 and 3.2.1.2.2 for further discussion and references.

Growth to Maturity
Larvae are epipelagic, occurring primarily in the upper 45 m of the water column shortly after hatching, moving downward in the water column as they grow. Juveniles occur mostly over the inner continental shelf at depths of 60 to 150 m. Adults occur in depths from the shallow water of the shoreline to 500 m. Average depth of occurrence tends to vary directly with age for at least the first few years of life, with mature fish concentrated on the outer continental shelf. Preferred substrate is soft sediment, from mud and clay to sand. See Sections 3.2.1.1.2 and 3.2.1.2.2 for further discussion and references.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	MT (Minimal or temporary effect)

The process of spawning/breeding pertains to the adult life history stage. The process of feeding pertains to the larval, juvenile, and adult life history stages. The process of growth to maturity pertains to the egg, larval, and juvenile stages. Therefore, the effects of reductions in habitat features on the processes of spawning/breeding, feeding, and growth to maturity can be described in terms of the effects on the egg, larval, juvenile, and adult life history stages. None of the five habitat features is relevant to Pacific cod at the egg or larval stage (although Pacific cod eggs are demersal, they do not appear to require three dimensional structure, and Pacific cod larvae appear to be largely pelagic). The habitat features most relevant to juvenile and adult Pacific cod are infaunal and epifaunal prey. The amounts of infauna and epifauna prey within the 75 percent concentration of adult BSAI Pacific cod are projected to be reduced by only 2 percent each and the amounts of infaunal and epifaunal prey within the 75 percent concentration of adult GOA Pacific cod are projected to be reduced by only 1 percent each (Table B.3-3). Because juvenile Pacific cod inhabit a subset of the adult habitat, it seems likely that the habitat features relevant to the juvenile stage would be reduced by similar amounts. As determined in the Draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the BSAI or GOA Pacific cod stocks to maintain themselves at or above their respective MSSTs. Therefore, the effects of the reductions in habitat features are either minimal or temporary in terms of the Pacific cod stocks' abilities to maintain themselves at or above MSST, including impacts mediated through the processes of spawning/breeding, feeding, and growth to maturity.

B.3.3.3 Sablefish (BSAI & GOA)

Habitat Connections

Spawning/Breeding
Spawning is pelagic at depths of 300 to 500 m near the edges of the continental slope (McFarlane and Nagata 1988), with eggs developing at depth and larvae developing near the surface as far offshore as 180 miles (290 km) (Wing 1997). Average spawning date based on otolith analysis is March 30 (Sigler et al. 2001). Sablefish are not thought to have any particular spawning grounds like halibut, so spawning likely is widespread along the upper continental slope. During surveys of the outer continental shelf, most young-of-the-year sablefish are caught in the central and eastern GOA (Sigler et al. 2001), implying that spawning is more likely to be successful in these areas.

Adult sablefish observed from a manned submersible were found on or within 1 m of the bottom (Krieger 1997). Sablefish demonstrate no particular habitat affiliation within broad habitat categories of gully and slope. They are distributed throughout these hydrographic features and occur in a wide range of habitats. They do not demonstrate any exclusivity like some rockfish species that use primarily rocky habitat.

Feeding

Larval sablefish feed on a variety of small zooplankton, ranging from copepod nauplii to small amphipods. Young-of-the-year are epipelagic and feed primarily on macrozooplankton and micronekton (e.g., euphausiids) (Sigler et al. 2002). Juveniles less than 60 cm feed primarily on euphausiids, shrimp, and cephalopods (Yang and Nelson 2000) while sablefish greater than 60 cm feed more on fish. Both juvenile and adult sablefish are considered opportunistic feeders. Fish most important to the sablefish diet include pollock, eulachon, capelin, Pacific herring, Pacific cod, Pacific sand lance, and some flatfish, with pollock being the most predominant (10 to 26 percent of prey weight, depending on year). Squid, euphasiids and jellyfish were also found, squid being the most important of the invertebrates (Yang and Nelson 2000). Feeding studies conducted in Oregon and California found that fish made up 76 percent of the diet (Laidig et al. 1997). Off the southwest coast of Vancouver Island, euphausiids dominated sablefish diet (Tanasichuk 1997).

To a lesser extent, adult sablefish also consume benthic prey including Polychaeta, Aphroditidae, Gastropoda, Bivalvia, Octopoda, *Diastylis* spp., Cirripedia, Caridea, *Eualus avinus*, Hippolytidae, Pandalidae, *Pandalus borealis*, *Pandalus goniurus*, *Pandalopsis dispar*, Crangonidae, *Crangon communis*, Paguridae, Asteroidea, Ophiuroidae, Majidae, *Chionocetes bairdi*, Sipunculae, Zoarcidae, Cottidae, and *Hemitripterus bolini* (Yang and Nelson 2000). Total percent weight of benthic prey consumed was 21.5 percent, 21.9 percent, and 10.6 percent in 1990, 1993, and 1996 respectively (Yang and Nelson 2000).

Growth to Maturity

Juveniles are pelagic and move into comparatively shallow nearshore areas where they spend the first 1 to 2 years (Rutecki and Varosi 1997). After their second summer, juveniles begin moving offshore, eventually reaching the upper continental slope as adults. Fish first appear on the upper continental slope, where the longline survey and longline fishery primarily occur, at age 2 and fork length about 50 to 53 cm, although only 10 percent are estimated to reach the slope at that young age. Fish are susceptible to trawl gear at an earlier age than to longline gear because trawl fisheries usually occur on the continental shelf and shelf break areas that are inhabited by younger fish.

Sablefish grow rapidly in early life, growing 1.2 mm d^{-1} during their first spring and summer (Sigler et al. 2001). Within 100 days after first increment formation, they average 120 mm. They reach average maximum lengths and weights of 69 cm and 3.4 kg for males and 83 cm and 6.2 kg for females. Fifty percent of females mature at 65 cm, while 50 percent of males are mature at 57 cm (Sasaki 1985), corresponding to ages 6.5 years for females and 5 years for males.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

The fishing effects of the current fishery management regime are either minimal or temporary based on the criteria that sablefish currently are above MSST. However caution is warranted. Sablefish are substantially dependent on benthic prey (18 percent of diet by weight), which may be adversely affected by fishing. Reductions of infauna and epifauna prey were less than 1 percent in three areas comprising

89 percent of the habitat where sablefish are concentrated (AI deep [10 percent of sablefish habitat], Gulf of Deep Shelf [47 percent] and GOA slope [32 percent]). Little is known about sablefish spawning habitat and effects of fishing on that habitat. Habitat requirements for growth to maturity are better known, but this knowledge is incomplete. Although sablefish do not appear substantially dependent on physical structure, living structure and coral are substantially reduced in much of the area where sablefish are concentrated. Living structure is reduced 5 to 8 percent and hard coral is reduced 12 to 31 percent in the same three areas comprising 89 percent of the habitat where sablefish are concentrated.

B.3.3.4 Atka Mackerel (BSAI & GOA)

Habitat Connections

Spawning/Breeding
Females deposit adhesive eggs in benthic nests in rocky crevices and hollows and among stones at depths less than 100 m. See Section 3.2.1.2.11 for further discussion and references.

Feeding
The adults feed mainly on pelagic euphasiids followed by calanoid copepods which are not one of the affected habitat features. See Section 3.2.1.2.11 for further discussion and references.

Growth to Maturity
Larvae are pelagic. Adults are semipelagic. Adults are demersal at times and are associated with rough, rocky habitat at depths of generally less than 200 m. They have exhibited strong diel vertical migrations with movements away from the bottom up into the water column. See Section 3.2.1.2.11 for further discussion and references.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

AI Atka mackerel eggs, juveniles and adults are found in benthic habitats; specifically, shallow, hard, non-living substrate. Overall, the AI shallow habitat comprises 50 percent of the area designated as the Atka mackerel 75 percent concentration distribution within the AI and GOA (Table B.3-3). Fifteen percent of the non-living substrate within the shallow Aleutian habitat is projected to be reduced under status quo (Table B.3-3). It is unclear what the impact of a 13 percent reduction of the non-living substrate within the shallow Aleutian habitat would be for Atka mackerel. However, as determined in the Draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the Atka mackerel stocks to maintain themselves at or above their respective MSSTs. Therefore, the effects of the reductions in habitat features on spawning/breeding are either minimal or temporary in terms of the Atka mackerel stocks' abilities to maintain themselves at or above MSST.

Adult Atka mackerel feed mainly on pelagic euphasiids followed by calanoid copepods, which are not one of the affected habitat features, therefore it is assumed that the 13 percent reduction of non-living structure within the AI shallow habitat would not have an impact (no effect), and the rating for feeding is also "MT."

GOA Atka mackerel eggs are presumed to be associated with shallow benthic habitats based on observations in the AI. GOA juveniles and adults are also associated with benthic habitats; specifically hard, non-living substrate on the deep shelf. Overall, the GOA shallow and deep shelf habitats comprise 4 and 5 percent, respectively, of the areas designated as the Atka mackerel 75 percent concentration distribution within the AI/GOA (Table B.3-3). Of this 4 and 5 percent, 1 percent of the non-living substrate within the shallow and deep shelf GOA habitat is projected to be reduced under status quo (Table B.3-3). It is assumed that this would have a negligible or minimal impact. Therefore the ratings for the effects of spawning/breeding and growth to maturity for GOA Atka mackerel are "MT." The adults feed mainly on pelagic euphasiids followed by calanoid copepods, which are not one of the affected habitat features. Therefore it is assumed that the 1 percent reduction of non-living structure within the GOA shallow and deep shelf habitats would not have an impact (no effect) and the rating for feeding is also "MT."

B.3.3.5 Yellowfin Sole (BSAI)

Habitat Connections

Spawning/Breeding
Yellowfin sole spawn pelagic eggs in nearshore areas . These eggs have been observed in the plankton (Nichol and Acuna 2000), but it is not known what role the seafloor habitat has in spawning success. See Section 3.2.1.2.3 for further discussion and references.

Adult Feeding
Adult feeding primarily occurs throughout the continental shelf on benthic infauna and epifauna during the summer. Adults feed upon infauna and epifauna such as clams, polychaete worms, amphipods, other marine worms and tunicates (Lang et al. 2003).

Growth to Maturity
Within the first year of life, yellowfin sole undergo metamorphosis from a free-swimming larvae stage to the familiar asymmetrical morphological life form characteristic of flatfish. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and for burrowing to achieve protection from predators (Moles and Norcross 1995). Growth from newly settled juveniles to mature adults is dependent on the infaunal and epifaunal supply of clams, polychaete worms, amphipods, other marine worms, and tunicates (Lang et al. 2003).

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	MT (Minimal or temporary effect)

The nearshore areas inhabited by early juveniles of yellowfin sole are mostly unaffected by current fishery activities. Adult and late juvenile yellowfin sole concentrations primarily overlap with the EBS sand (61 percent and sand/mud 39 percent) habitats on the inner- and mid-shelf areas (Table B.3-3). Projected equilibrium reductions in epifauna and infaunal prey in those overlaps were less than 1 percent for sand and 3 percent for sand/mud. The reduction in living structure is estimated at only 5 to 18 percent for the summer distribution (relevant since 10 percent of the yellowfin sole diet consists of tunicates). Given this level of disturbance, it is unlikely that adult feeding would be negatively impacted. The yellowfin sole stock is currently at a high level of abundance (Wilderbuer and Nichol 2002) and well above the MSST. No declines in weight and/or length at age have been documented in this stock for year classes observed over the past 22 years, which might be expected if the quality of the benthic feeding habitat was degraded. As determined in the Draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the yellowfin sole stocks to maintain themselves at or above their respective MSSTs. Therefore, the effects of the reductions in habitat features are either minimal or temporary in terms of the yellowfin sole stocks' abilities to maintain themselves at or above MSST. The effects of fishing are, therefore, not anticipated to have an impact on spawning/breeding, adult feeding, or juvenile survival and growth to maturity.

B.3.3.6 Greenland Turbot (BSAI)

Habitat Connections

Spawning/Breeding
Eggs are bathypelagic and spawning is widespread throughout the EBS slope. It is not known what role the seafloor habitat has in spawning success. See Section 3.2.1.2.4 for further discussion and references.

Adult Feeding
Adult feed primarily on pollock, squid, and deep water fish species during the summer throughout the deep slope waters, and to a lesser extent on the upper slope/shelf margins. Most of the Greenland turbot feeding behavior is observed to take place off the bottom and is not related to benthic food availability.

Growth to Maturity
Within the first year of life, Greenland turbot undergo metamorphosis from a free-swimming larvae stage to the familiar asymmetrical morphological life form characteristic of flatfish. Upon settlement in nearshore areas, juvenile flatfish preferentially select sediment suitable for feeding on meiofaunal prey and for burrowing to achieve protection from predators (Moles and Norcross 1995). Growth from newly settled juveniles to mature adults is dependent on the infaunal supply of polychaete worms, amphipods, and other marine worms.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	MT (Minimal or temporary effect)

The nearshore areas inhabited by early juveniles of Greenland turbot are mostly unaffected by current fishery activities. Greenland turbot adult and late juvenile concentrations primarily overlap (65 percent with sand/mud habitats in the BSAI (Table B.3-3). Infaunal prey reductions would affect growth to maturity for late juvenile Greenland turbot. Infaunal prey reductions in the concentration areas in sand/mud habitats of the EBS are predicted to be 2 percent. This benthic disturbance is not thought to be relevant to adult Greenland turbot feeding success since fish species found in their diet are not directly associated with the seafloor. As determined in the Draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the Greenland turbot stocks to maintain themselves at or above their respective MSSTs. Therefore, the effects of the reductions in habitat features are either minimal or temporary in terms of the Greenland turbot stocks' abilities to maintain themselves at or above MSST.

B.3.3.7 Arrowtooth Flounder (BSAI & GOA)

Habitat Connections

Spawning/Breeding
Eggs are semi-demersal and spawning is widespread throughout the outer shelf. It is not known what role the seafloor habitat has in spawning success. See Section 3.2.1.1.5 for further discussion and references.

Adult Feeding
Adults feed primarily on fish, squid, pandalid and cragonid shrimp, and euphausids during the summer throughout the outer continental shelf and upper slope areas. Therefore benthic epifauna is of some importance in their diet.

Growth to Maturity
Within the first year of life, arrowtooth flounder undergo metamorphosis from a free-swimming larvae stage to the familiar asymmetrical morphological life form characteristic of flatfish. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and for burrowing to achieve protection from predators (Moles and Norcross 1995). Growth from newly settled juveniles to mature adults is dependent on the infaunal supply of polychaete worms, amphipods, and other marine worms.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	MT (Minimal or temporary effect)

The nearshore areas inhabited by arrowtooth flounder early juveniles are mostly unaffected by current fishery activities. Adult and late juvenile concentrations primarily overlap the EBS sand/mud habitat (34 percent) and the GOA deep shelf habitat (35 percent) (Table B.3-3). Overall, epifaunal prey reduction in those overlaps is predicted to be 3 percent for EBS sand/mud and 1 percent for GOA deep shelf habitats. Given this level of disturbance, and the large percentage of the diet of arrowtooth flounder not including epifauna prey, it is unlikely that the adult feeding would be negatively impacted. The arrowtooth flounder stock is currently at a high level of abundance due to sustained above-average recruitment in the 1980s and 1990s (Turnock et al. 2002) No change in weight and length at age has been observed in this stock from bottom trawl surveys conducted from 1984 through 2001. As determined in the Draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the arrowtooth flounder stocks to maintain themselves at or above their respective MSSTs. Therefore, the effects of the reductions in habitat features are either minimal or temporary in terms of the arrowtooth flounder stocks' abilities to maintain themselves at or above MSST. The effects of fishing are, therefore, not anticipated to have an impact on spawning, adult feeding, or juvenile survival and growth to maturity.

B.3.3.8 Rock Sole (BSAI)

Habitat Connections

Spawning/Breeding
Although eggs are demersal and adhesive (specific gravity of 1.047, Hart 1971), it is not known what role the habitat has in spawning success. See Section 3.2.1.2.6 for further discussion and references.

Adult Feeding
Adults feed primarily on the infaunal supply of polychaete worms, amphipods, other marine worms, and sandlance (Lang et al. 2003) during the summer throughout the continental shelf.

Growth to Maturity
Within the first year of life, rock sole undergo a metamorphosis from free-swimming larvae to the familiar asymmetrical morphological life form characteristic of flatfish. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and burrowing to achieve protection from predators (Moles and Norcross 1995). Growth from newly settled juveniles to mature adults is dependent on the infaunal supply of polychaete worms, amphipods, other marine worms, and sandlance (Lang et al. 2003).

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	MT (Minimal or temporary effect)

The nearshore areas inhabited by rock sole early juveniles are mostly unaffected by current fishery activities. Adult and late juvenile rock sole in the BSAI are primarily concentrated in sand/mud (41 percent) and sand (37 percent) habitats and are affected by levels of infaunal prey (Table B.3-3). Predicted reductions of infaunal prey in those concentration overlaps are 3 percent (sand/mud) and less than 1 percent (sand). Given this level of disturbance, it is unlikely that adult feeding would be negatively impacted. The rock sole stock is currently at a high level of abundance due to sustained above-average recruitment in the 1980s (Wilderbuer and Walters 2002). The productivity of the stock is currently believed to correspond to favorable atmospheric forces in which larvae are advected to nearshore nursery areas (Wilderbuer et al. 2002). A decline in weight and length at age has been documented in this stock for year classes between 1979 and 1987 (Walters and Wilderbuer 2000), but was hypothesized to be a density dependent response to a rapid increase in an expanding population. Individual rock sole may have been displaced beyond favorable feeding habitat, rather than by a reduction in the quality of habitat. As determined in the Draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the rock sole stocks to maintain themselves at or above their respective MSSTs. Therefore, the effects of the reductions in habitat features are either minimal or temporary in terms of the rock sole stocks’ abilities to maintain themselves at or above MSST. The effects of fishing are, therefore, not anticipated to have an impact on spawning, adult feeding, or juvenile survival and growth to maturity.

B.3.3.9 Flathead Sole (BSAI)

Habitat Connections

Spawning/Breeding
Flathead sole spawn large pelagic eggs in deeper waters near the continental shelf margin which develop into planktonic larvae. It is not known what role the habitat has in spawning success. See Section 3.2.1.2.7 for further discussion and references.

Adult Feeding
Adult feeding primarily occurs during summer on the middle and outer continental shelf areas on benthic infauna, epifauna, and certain fish species. They are dependent upon an infaunal and epifaunal supply of polychaete worms, mysids, brittle stars, shrimp, and hermit crabs (Lang et al. 2003).

Growth to Maturity
Within the first year of life, flathead sole undergo metamorphosis from a free-swimming larvae state to the familiar asymmetrical morphological life form characteristic of flatfish. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and for burrowing to achieve protection from predators (Moles and Norcross 1995). Growth from newly settled juveniles to mature adults is dependent on the infauna supply of polychaete worms, amphipods, and other marine worms (Lang et al. 2003).

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	MT (Minimal or temporary effect)

The nearshore areas inhabited by flathead sole early juveniles are mostly unaffected by current fishery activities. Adult and late juvenile flathead sole in the BSAI are primarily concentrated in sand/mud habitat (41 percent) and would be affected by reductions in infaunal and epifaunal prey (Table B.3-3). The predicted reductions for infaunal and epifaunal prey in the concentration overlap for EBS sand/mud habitat are 3 and 2 percent, respectively. Given this level of disturbance, it is unlikely that the adult feeding would be negatively impacted. The flathead sole stock is currently at a high level of abundance due to sustained above-average recruitment in the 1980s (Wilderbuer and Walters 2002). The productivity of the stock is currently believed to correspond to favorable atmospheric forcing whereby larvae are advected to nearshore nursery areas (Spencer et al. 2002). A decline in weight and length at age has not been documented in this stock during 22 years of observation on trawl surveys (Spencer et al. 2002). As determined in the Draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the flathead sole stock to maintain themselves at or above their respective MSSTs. Therefore, the effects of the reductions in habitat features are either minimal or temporary in terms of the flathead sole stocks' abilities to maintain themselves at or above MSST. The effects of fishing are, therefore, not anticipated to have an impact on spawning, adult feeding, or juvenile survival and growth to maturity.

B.3.3.10 Flathead Sole (GOA)

Habitat Connections

Spawning/Breeding
Flathead sole spawn large pelagic eggs in deeper waters near the continental shelf margin which then develop into planktonic larvae. It is not known what role the habitat has in spawning success. See Section 3.2.1.1.7 for further discussion and references.

Adult Feeding
Adult feeding primarily occurs during summer on the middle and outer continental shelf areas on benthic infauna, epifauna, and certain fish species. They are therefore dependent on the infaunal and epifauna supply of polychaete worms, mysids, brittle stars, shrimp, and hermit crabs.

Growth to Maturity
Within the first year of life, flathead sole undergo metamorphosis from a free-swimming larvae stage to the familiar asymmetrical morphological life form characteristic of flatfish. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and for burrowing to achieve protection from predators (Moles and Norcross 1995). Growth from newly settled juveniles to mature adults is dependent on the supply of infauna prey such as polychaete worms, amphipods, and other marine worms (Lang et al. 2003).

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	MT (Minimal or temporary effect)

The nearshore areas inhabited by flathead sole early juveniles are mostly unaffected by current fishery activities. Adult and late juvenile flathead sole concentrations in the GOA primarily overlap with deepwater shelf (15 percent) and shallow water habitats (14 percent) (Table B.3-3). This species would be affected by reductions in the availability of infaunal and epifaunal prey. Reductions for both infaunal and epifaunal prey are predicted to be reduced 1 percent in concentration overlaps with deepwater shelf areas and less than 1 percent in shallow water habitat. Given this level of disturbance, it is unlikely that the adult feeding would be negatively impacted. Additionally, stock assessment modeling indicates that flathead sole are at a stable level above the MSST threshold (Turnock et al. 2002). As determined in the Draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the flathead sole stock to maintain themselves at or above their respective MSSTs. Therefore, the effects of the reductions in habitat features are either minimal or temporary in terms of the flathead sole stocks' abilities to maintain themselves at or above MSST. Trawl survey abundance estimates also indicate a stable level of biomass since 1984. The effects of fishing are, therefore, not anticipated to have an impact on spawning, adult feeding, or juvenile survival and growth to maturity.

B.3.3.11 Rex Sole (GOA)

Habitat Connections

Spawning/Breeding
Rex sole spawn pelagic eggs and it is not known what role the habitat has in spawning success. See Appendix F for further discussion and references.

Adult Feeding
Adult feeding primarily occurs during summer on the continental slope and to a lesser extent on the outer shelf area. They are thought to be dependent on the infauna supply of polychaete worms, amphipods, and other marine worms.

Growth to Maturity
Within the first year of life, rex sole undergo metamorphosis from a free-swimming larval stage to the familiar asymmetrical morphological life form characteristic of flatfish. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and for burrowing for protection from predators (Moles and Norcross 1995). Growth from newly settled juveniles to mature adults is dependent on the infauna supply of polychaete worms, amphipods, and other marine worms.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

The nearshore areas inhabited by rex sole early juveniles are mostly unaffected by current fishery activities. Adult and late juvenile rex sole concentrations in the GOA primarily overlap with deepwater shelf habitat (51 percent) and slope habitat (14 percent) (Table B.3-3). These fish would be affected by reductions in infaunal prey. However, the predicted reductions in these concentration overlaps are 1 percent for deepwater shelf habitat and 1 percent for slope habitat. The level of information available for rex sole is insufficient to estimate the stock size relative to MSST. Trawl survey abundance estimates indicate a stable level of biomass since 1984. Since the MSST level for rex sole is unknown, the impacts of the effects of fishing on the habitat required for spawning, adult feeding, or juvenile survival and growth to maturity are unknown.

B.3.3.12 Alaska Plaice (BSAI)

Habitat Connections

Spawning/Breeding
Alaska plaice spawn eggs which are transparent and pelagic (Zhang et al. 1998) and it is not known what role the seafloor habitat has in spawning success. See Section 3.2.1.2.8 for further discussion and references.

Adult Feeding
Adult feeding primarily occurs during summer throughout the continental shelf on benthic infauna and are therefore dependent on the infaunal supply of polychaete worms, marine worms and, to a lesser extent, bivalues.

Growth to Maturity
Within the first year of life, Alaska plaice undergo a metamorphosis from a free-swimming larval stage to the familiar asymmetrical morphological life form characteristic of flatfish. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and for burrowing to achieve protection from predators (Moles and Norcross 1995). Growth from newly settled juveniles to mature adults is dependent on the infauna supply of polychaete worms, other marine worms, and bivalves.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	MT (Minimal or temporary effect)

The nearshore areas inhabited by Alaska plaice early juveniles are mostly unaffected by current fishery activities. Adult and late juvenile Alaska plaice concentrations in the BSAI primarily overlap with the EBS sand habitat (42 percent) and the EBS sand/mud habitat (52 percent) (Table B.3-3). These fish would be affected by reductions in infaunal prey. However, the levels of reduction in those concentration overlaps are predicted to be less than 1 percent for EBS sand and 2 percent for EBS sand/mud habitat. Given this level of disturbance, it is unlikely that the adult feeding would be negatively impacted. The Alaska plaice stock is currently at a high level of abundance (Spencer et al. 2002), and well above the MSST. As determined in the Draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the Alaska plaice stock to maintain themselves at or above their respective MSSTs. Therefore, the effects of the reductions in habitat features are either minimal or temporary in terms of the Alaska plaice stocks' abilities to maintain themselves at or above MSST. There have been no observations of a decline in length or weight at age for this stock over the 22 years of trawl survey sampling. The effects of fishing are, therefore, not anticipated to have an impact on spawning, adult feeding, or juvenile survival and growth to maturity.

B.3.3.13 Shallow Water Flatfish (GOA)

Habitat Connections

Eight species of flatfish comprise the shallow water management complex. For this discussion of habitat relating to life history and biology, the southern rock sole is used to characterize the group of species. The two species of rock sole are, by far, the dominant species in this group, both in terms of biomass and harvest. Their habitat requirements are not expected to be so different from other species in this group to require separate analysis. The seafloor habitat is associated with southern rock sole settlement, growth to maturity, and adult feeding.

Spawning/Breeding
Although eggs are demersal and adhesive (specific gravity of 1. 047, Hart 1971), it is not known what role the habitat has in spawning success. See Appendix F for further discussion and references.

Adult Feeding
Adult feeding primarily occurs during summer throughout the continental shelf on benthic infauna and are therefore dependent on the infauna supply of polychaete worms, amphipods, other marine worms, and sandlance in that area (Lang et al. 2003).

Growth to Maturity
Within the first year of life, rock sole undergo a metamorphosis from a free-swimming larval stage to the familiar asymmetrical morphological life form characteristic of flatfish. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and for burrowing to achieve protection from predators (Moles and Norcross 1995). Growth from newly settled juveniles to mature adults is dependent on the infauna supply of polychaete worms, amphipods, other marine worms, and sandlance (Lang et al. 2003).

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

The nearshore areas inhabited by early juveniles of GOA shallow water flatfish are mostly unaffected by current fishery activities. Adult and late juvenile rock sole concentrations, as a proxy for GOA shallow water flatfish, primarily overlap with shallow water habitats (13 percent) (Table B.3-3). The predicted reduction of infaunal prey in that concentration overlap is 1 percent. Given this level of disturbance, it is unlikely that the adult feeding would be negatively impacted. The level of information available for rock sole and the other species of the shallow water complex are insufficient to estimate the stock size relative to MSST, although trawl survey abundance estimates indicate a stable level of biomass since 1984. Since the MSST levels for species in this complex are unknown, the impacts of the effects of fishing on the habitat required for spawning, adult feeding, or juvenile survival and growth to maturity are unknown.

B.3.3.14 Deep Water Flatfish (GOA)

Habitat Connections

Three species comprise this management group: Greenland turbot, Dover sole, and deep sea sole. For this discussion of habitat relating to life history and biology, Dover sole is used to characterize the group of species. Dover sole are, by far, the dominant species in this group, both in terms of biomass and harvest. Their habitat requirements are not expected to be so different from other species in this group to require separate analysis. The seafloor habitat is associated with Dover sole settlement, growth to maturity, and adult feeding.

Spawning/Breeding
Dover sole spawn pelagic eggs, and it is not known what role the habitat has in spawning success. See Appendix F for further discussion and references.

Adult Feeding
Adult feeding primarily occurs during summer on the continental slope and to a lesser extent on the outer shelf area. They are thought to be dependent on the infauna supply of polychaete worms, amphipods, and other marine worms.

Growth to Maturity
Within the first 2 years of life, Dover sole undergo metamorphosis from a free-swimming larval stage to the familiar asymmetrical morphological life form characteristic of flatfish. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and for burrowing

for protection from predators (Moles and Norcross 1995). Growth from newly settled juveniles to mature adults is dependent on the infauna supply of polychaete worms, amphipods, and other marine worms.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

The nearshore areas inhabited by early juveniles of GOA deep water flatfish are mostly unaffected by current fishery activities. Adult and late juvenile Dover sole concentrations in the GOA, as a proxy for GOA deep water flatfish, primarily overlap with deepwater shelf habitat (58 percent), slope habitat (19 percent), and shallow water habitat (21 percent) (Table B.3-3). This species is dependent on infaunal prey. However, reductions of infaunal prey in those concentration overlaps are predicted to be 1 percent for each of those habitats. Given this level of disturbance, it is unlikely that the adult feeding would be negatively impacted. The level of information available for Dover sole and the other species of the deep water complex are insufficient to estimate the stock size relative to MSST. Trawl survey abundance estimates indicate a stable level of biomass since 1984. Since the MSST levels for species in this complex are unknown, the impacts of the effects of fishing on the habitat required for spawning, adult feeding, or juvenile survival and growth to maturity are unknown.

B.3.3.15 Pacific Ocean Perch (BSAI)

Habitat Connections

Spawning/Breeding
Adult Pacific ocean perch have been found in pebble substrates with little relief (Kreiger 1993). Adult Pacific ocean perch are viviparous, with parturition (larval release)occurring in the late winter to early spring. Gunderson (1971) found that Pacific ocean perch off Queen Charlotte Island, British Columbia, were found in shallower depths in the summer than during other times of year.

Feeding
Pacific ocean perch are plankton feeders, with juvenile Pacific ocean perch eating calanoid copepods and adults eating largely euphausids (Yang 1993, 1996).

Growth to Maturity
Information on the habitat of juvenile Pacific ocean perch is available from a limited number of submersible studies. Straty (1987) found that juvenile Pacific ocean perch occupied rocky coastal areas off southeast Alaska at depths of 134 to 171 m; the ranges in age and size of these juvenile were 1 to 3 years and 78 to 164 mm. These juvenile Pacific ocean perch, and other juvenile rockfish, took refuge in rocky areas when alarmed by the movement of the submersible. Carlson and Straty (1981) also noted the use of coastal rocky habitats by juvenile rockfish, and Kreiger (1993) noted the use of rugged habitat (cobble with boulders) by small (less than 25 cm) Pacific ocean perch.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	MT (Minimal or temporary effect)

For those areas where 95 percent of the adult Pacific ocean perch population occurs (general distribution), the potential reduction in living structure and non-living structure along the EBS slope were projected to be 12 and 4 percent, respectively. In the AI deep areas (200 to 1,000 m), the potential reduction in living structure and non-living structure is projected to be 12 and 4 percent, respectively. In the AI shallow areas, the potential reduction in living structure and non-living structure is projected to be 13 and 8 percent, respectively. A reduction in living structure and non-living structure would be expected to have a minimal and temporary effect on spawning/breeding and feeding due to the lack of strong associations of these benthic features with adult Pacific ocean perch. A reduction in living structure and non-living structure may affect growth to maturity due to a reduction of refuge habitat for juvenile Pacific ocean perch. However, estimates of age 3 recruits, obtained from an age-structured population model, indicates that recruitment increased during the 1980s (Spencer and Ianelli et al. 2002) when a large portion of the impacts of fishing on EFH would have been expected. Thus, this suggests that the effects of fishing on growth and survival to maturity were not sufficient to prevent the population from increasing. As determined in the Draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the Pacific ocean perch stock to maintain themselves at or above their respective MSSTs. Therefore, the effects of the reductions in habitat features are either minimal or temporary in terms of the Pacific ocean perch stocks' abilities to maintain themselves at or above MSST.

B.3.3.16 Pacific Ocean Perch (GOA)

Habitat Connections

Though more is known about the life history of Pacific ocean perch than about other rockfish species (Kendall and Lenarz 1986), much uncertainty still exists about specific habitat preferences. Pacific ocean perch is primarily a demersal species that inhabits the outer continental shelf and upper continental slope regions of the North Pacific Ocean and the EBS from southern California to northern Honshu Island, Japan (Allen and Smith 1988). The species appears to be most abundant in northern British Columbia, the GOA, and the AI. As adults, they generally live on or near the seafloor at depths ranging from about 150 to 420 m.

Spawning/Breeding

Similar to other rockfish, Pacific ocean perch have internal fertilization and release live young Insemination occurs in the fall, and release of larvae occurs in April or May. Following insemination, females appear to migrate into deeper waters (500 to 700 m), often near the mouths of submarine gullies, and stay there until the time of larval release (Love et al. 2002). Pacific ocean perch larvae are thought to be pelagic and drift with the current, but larval studies of rockfish have been hindered by difficulties in species identification. There is no evidence that links habitat features with the ability of Pacific ocean perch to accomplish the spawning/breeding process.

Feeding

Pacific ocean perch are mostly planktivorous (Yang 1993, 1996, Yang and Nelson 2000). Small juveniles feed on calanoid copepods; large juveniles and adults feed on euphausiids, and to a lesser degree, pandalid shrimp and squids. Large offshore euphausiids are not directly associated with the bottom but rather are thought to be advected onshore near bottom at the upstream ends of underwater canyons where they become easy prey for planktivorous fishes (Brodeur 2001). Predators of Pacific ocean perch are sablefish, Pacific halibut, and sperm whales (Major and Shippen 1970). There is no evidence that links the habitat features with the ability of Pacific ocean perch to accomplish the feeding process.

Growth to Maturity
Post-larval and early young-of-the-year Pacific ocean perch have been positively identified in offshore, surface waters of the GOA (Gharrett et al. 2002). Consequently post-larval and early young-of-the-year Pacific ocean perch are thought to be pelagic and there is no evidence that links habitat features with the ability of Pacific ocean perch to accomplish the growth to maturity process during the post larval or early juvenile stages.

Later stage juveniles of reddish rockfish believed to be Pacific ocean perch have been observed in an inshore, demersal habitat (Carlson and Straty 1981; Straty 1987; Pearcy et al. 1989; Krieger 1993). Carlson and Straty (1981) observed small reddish rockfish believed to be juvenile Pacific ocean perch with a submersible at 90 to 100 m in offshore Southeast Alaska. The reddish rockfish were observed along rocky areas exposed to open sea conditions that ranged from rugged steep rocky pinnacles to boulder fields interspersed with gravel beds (Carlson and Straty 1981). Krieger (1993) observed small reddish rockfish believed to be juvenile Pacific ocean perch with a submersible at 188 to 290 m in offshore Southeast Alaska. The highest densities of small reddish rockfish were observed at untrawlable sites over rugged habitat including cobble, cobble and boulders, and among ledges and coral (type of coral was not specified) (Krieger 1993). Large schools of juvenile Pacific ocean perch have also been found on the shelf in other areas of the GOA including Albatross Bank and Shumagin Bank (Westrheim 1970). Consequently there is evidence that links living and non-living structure, with the ability of Pacific ocean perch to accomplish the growth to maturity process during the later demersal juvenile stage. Based upon the depth distributions and substrate types described above, these links most likely occur in shallow (0 to 100 m), deeper shelf areas (100 to 300 m) and slope (200 to 1,000 m) habitat types over hard (pebble to rock) substrates and are included as such in the GOA Pacific ocean perch connections table (Table B.3-1).

As they mature into adults, juveniles move to progressively deeper waters of the continental shelf and are often associated with smoother more trawlable bottom. Length frequencies of Pacific ocean perch captured in NMFS bottom trawl surveys and observed in commercial fishery bottom trawl catches indicate that older juveniles are often found together with adults at shallower locations of the continental slope in the summer months (Pers comm Dave Clausen[1]). Commercial fishing data indicate that adult Pacific ocean perch are most prevalent on the shelf break (100 to 200 m), slope (more than 200 m), and inside major gullies and trenches (200 to 500 m) running perpendicular to the shelf break (Lunsford 1999, Lunsford et al. 2001). Krieger (1993) noted that most large (longer than 25 cm) rockfish identified as adult Pacific ocean perch were associated with pebble substrate on flat or low-relief bottom. Other studies with trawl and sunken gill nets have found Pacific ocean perch predominantly over relatively smooth, trawlable bottoms (bottom type was not identified) (Westrheim 1970; Matthews et al. 1989). In the EBS and GOA, Pacific ocean perch have also been observed associated with forests of epibenthic sea whips (*Halipteris willemoesi*, Brodeur 2001), and sea pens (possibly misidentified sea whips) (Krieger 1993). Consequently there is evidence that links the habitat features, living structure non-living structure, with the ability of Pacific ocean perch to accomplish the growth to maturity process during the demersal adult stage. Based upon the depth distributions and substrate types described above, these links most likely occur in deeper shelf areas (100 to 300 m) and slope (200 to 1,000 m) habitat types over soft (sand and gravel) and hard (pebble to rock) substrates and are included as such in the GOA Pacific ocean perch connections table (Table B.3-1).

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

For those areas where 95 percent of the adult Pacific ocean perch population occurs (general distribution), the potential reduction in living and non-living structure along the GOA shallow shelf (less than 100 m) was projected to be 5 and 1 percent, respectively. In the GOA deep shelf (100 to 300 m), the potential reduction in living and non-living structure is projected to be 7 and 1 percent, respectively. In the GOA slope (200 to 1,000 m), the potential reduction in living and non-living structure is projected to be 6 and 1 percent, respectively. A reduction in living and non-living structure would be expected to have no effect on spawning/breeding and feeding due to the lack of strong associations of these benthic features with GOA Pacific ocean perch. A reduction in living and non-living structure may reasonably jeopardize growth to maturity due to a reduction of refuge habitat for juvenile GOA Pacific ocean perch. However, recruitment estimates obtained from an age-structured population model show relatively high recruitments in the late 1980s and the late 1990s (Heifetz et al. 2002). Recruitment in the late 1990s has been sufficient to rebuild the stock from apparent overfishing in the 1960s and continued low levels in the 1980s (Heifetz et al. 2002). This suggests that the cumulative effects of fishing activities on habitat were not sufficient to prevent the population from maintaining itself above MSST. Under the assumption that the potential reductions in living and non-living structure is not sufficient to jeopardize the stock to sustain itself at or above the MSST level there is no effect of fishing on the growth and survival to maturity life-history process. As determined in the Draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the Pacific ocean perch stock to maintain themselves at or above their respective MSSTs. Therefore, the effects of the reductions in habitat features are either minimal or temporary in terms of the Pacific ocean perch stocks' abilities to maintain themselves at or above MSST. There is also no evidence to suggest that the potential reductions in living and non-living structure on growth and survival to maturity affects the ability of GOA Pacific ocean perch to fulfill its role in a healthy ecosystem.

B.3.3.17 Shortraker and Rougheye Rockfish (BSAI)

Habitat Connections

Spawning/Breeding
Adult rougheye/shortraker rockfish have been found at depths of 300 to 500 m in AI trawl surveys. In a submersible study off southeast Alaska, Kreiger and Ito (1999) found that rougheye/shortraker rockfish were associated with habitats containing frequent boulders, steep slopes (more than 20°) and sand-mud substrates. Rougheye/shortraker rockfish are viviparous, with parturition occurring in the spring. Much of the data collected on rougheye/shortraker rockfish was obtained during surveys and fisheries in the summer months, when rougheye/shortraker rockfish are not expected to be either breeding or spawning.

Feeding
Pandalid and hippolytid shrimp are the largest components of the rougheye rockfish diet (Yang 1993, 1996). The diet of shortraker rockfish is largely unknown, but a limited number of samples suggest that squid is a major component. Kreiger and Ito (1999) hypothesized that shortraker/rougheye rockfish may use boulders to avoid currents and/or capture prey.

Growth to Maturity
Little information is available on the habitat of juvenile rougheye/shortraker rockfish. Studies using submersibles have indicated that several species of rockfish appear to use rocky, shallower habitats during their juvenile stage (Carlson and Straty 1981, Straty 1987, Kreiger 1993). Although these studies did not specifically observe rougheye/shortraker rockfish, it is reasonable to suspect that juvenile rougheye and shortraker rockfish also use these shallower habitats as refuge areas. NMFS trawl surveys suggest that smaller rougheye (less than 35 cm) occur in shallower areas than the larger adults.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

For those areas where 95 percent of the adult shortraker/rougheye population occurs (general distribution), the potential reductions in living structure, non-living structure, and epifauna prey along the EBS slope were projected to be 11 percent, 3 percent, and 2 percent. In the AI deep areas (200 to 1,000 m), the potential reductions in living structure, non-living structure, and epifauna prey were projected to be 3 percent, 2 percent, and less than 1 percent. In the AI shallow areas, the potential reductions in these three habitat features were projected to be 7 percent, 4 percent, and 1 percent. The slight reductions in epifauna prey would be expected to have minimal and temporary effect on the feeding of rougheye/shortraker rockfish. However, it is unknown whether such potential habitat use is so obligatory that the small projected habitat effects (1.1 to 11.5 percent) would affect the ability of the stock to sustain itself above the MSST.

B.3.3.18 Shortraker and Rougheye Rockfish (GOA)

In 1991, the Council divided the slope rockfish assemblage in the GOA into three management subgroups: Pacific ocean perch, shortraker/rougheye, and all other species of slope rockfish. In 1993, a fourth management subgroup, northern rockfish, was also created. Separate sections have been done to address Pacific ocean perch and northern rockfish. The shortraker/rougheye rockfish management group in the GOA comprises two species: shortraker rockfish (*Sebastes borealis*) and rougheye rockfish (*S. aleutianus*). As adults, these two species often co-occur in trawl hauls on the upper continental slope, and they are sometimes difficult to visually differentiate. For these reasons, they are grouped together into a single management category in the GOA.

The 19 remaining species of slope rockfish are grouped into the “other slope rockfish” management subgroup. Harlequin, sharpchin, redstripe, silvergrey, and yellowmouth rockfish have been the predominant species caught in the commercial fishery. Catches have remained low for this group since 1998 because of the trawl closure that began that year in the eastern GOA. Most of the biomass of “other slope rockfish” species is located in this area and therefore the commercial catch of this group is minor. Because of the abundance and commercial importance of shortraker/rougheye rockfish in the GOA, this section will focus exclusively on the EFH for this management group and “other slope rockfish” will not be mentioned.

Habitat Connections

Except for adults, habitat preferences for shortraker and rougheye rockfish are either unknown or very poorly known (Table B.3-1). Similar to all other species of *Sebastes*, the egg stage is completed inside the female. The larval stage is pelagic, but larval studies are hindered by the fact that the larvae at present can only be positively identified by genetic analysis, which is both expensive and labor-intensive. The post-larval and early young-of-the-year stages also appear to be pelagic for both species (Matarese et al. 1989; Gharrett et al. 2002). Very few juvenile (less than 40 cm fork length) shortraker rockfish have ever been caught in the GOA, so the habitat for this life stage is completely unknown. In contrast, juvenile rougheye rockfish 15 to 40 cm in fork length are frequently caught in GOA trawl surveys. They are generally found at shallower, more inshore areas than adults, and have been taken in variety of locations, ranging from inshore fiords to offshore waters of the continental shelf. In Table B.3-1, they would occur in the shallow and deeper shelf, but their habitat preference within this environment has not been documented. They certainly are found in reasonably flat, trawlable bottom areas, but it is not known whether they prefer soft or hard substrate, or if the fish associate with any habitat feature. Consequently, the spaces for "older juvenile" rougheye rockfish in the shallow and deep shelf in Table B.3-1 have been left blank. The habitat preference for adults of both species has been fairly well documented. Adults are concentrated in a narrow band along the continental slope, with highest catch rates generally at depths of 300 to 400 m in longline surveys (Zenger and Sigler 1992) and at depths of 300 to 500 m in trawl surveys and in the commercial fishery (Ito 1999). In the GOA, these areas on the slope are known to be generally steep, rocky, and difficult to trawl. Observations from a manned submersible in this habitat indicate the fish prefer steep slopes where they are often associated with boulders (Krieger and Ito 1999). Submersible studies have also shown adults of the two species are sometimes associated with *Primnoa* spp. coral (Krieger and Wing 2002). Because of the rocky nature of their slope habitat, and the fishes' associations with boulders and corals, Table B.3-1 shows adult shortraker and rougheye rockfish as occurring on the slope on hard substrate associated with non-living structure and with corals.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	U (Unknown effect)

Spawning/Breeding—There is no information on reproductive behavior for either species, except that parturition is believed to occur in February through August for shortraker rockfish, and in December through April for rougheye rockfish (McDermott 1994). Because of this lack of knowledge, the effects of fishing on spawning/breeding of these fish is unknown (Table B.3-1).

Feeding—Food habit studies conducted by Yang and Nelson (2000) indicate that the diet of rougheye rockfish is primarily shrimp, and that various fish species are also consumed. The diet of shortraker rockfish is not well known; however, based on a small number of samples, the diet appears to be mostly squid, shrimp, and deepwater fish such as myctophids. Because these prey items are all pelagic or semi-pelagic in their distribution and are also small in size, they are not generally not vulnerable to substantial impacts from bottom fishing gear. Consequently, fishing probably has little or no direct effect on prey availability to adult shortraker and rougheye rockfish.

Growth to maturity—As previously discussed, habitat requirements for the various life stages of both species are mostly unknown. Juvenile shortraker rockfish have almost never been caught on any fishing gear, so it is likely that fishing does not occur (and thus has no direct effect) on whatever habitat they do occupy. Juvenile rougheye rockfish are frequently taken in bottom trawls, but their preferred habitat and whether they associate with any habitat features is uncertain. In contrast, adults of both species are known to particularly inhabit steep, rocky areas of the continental slope, and they have been observed in association with boulders and corals (Krieger and Ito 1999; Krieger and Wing 2002). Bottom trawling is known to displace boulders and damage corals, and it could have a negative impact on growth and survival of these fish. However, to really evaluate this possible problem, additional research is needed to determine how essential these associations are to the health of the stocks and how much damage is actually occurring due to fishing gear. Taking into consideration all these factors, a rating of "unknown" is given to the "growth to maturity" issue in Table B.3-1.

B.3.3.19 Northern Rockfish (BSAI)

Habitat Connections

Spawning/Breeding
Little is known of the spawning/breeding habitat of northern rockfish. In the AI, observations from NMFS trawl surveys indicates that adults are generally found at depths of 100 to 150 m over generally hard substrates. Northern rockfish are viviparous, and observations on trawl surveys in the GOA indicate that parturition occurs in the spring. Much of the data collected on northern rockfish were obtained during surveys and fisheries in the summer months, when northern rockfish are not expected to be either breeding or spawning.

Feeding
Northern rockfish are plankton feeders, eating largely euphausids but also copepods, hermit crabs, and shrimp (Yang 1993).

Growth to Maturity
Little information is available on the habitat of juvenile northern rockfish. Studies using submersibles have indicated that several species of rockfish appear to use rocky, shallower habitats during their juvenile stage (Carlson and Straty 1981, Straty 1987, Kreiger 1993). Although these studies did not specifically observe northern rockfish, it is reasonable to suspect that juvenile northern rockfish also use these shallower habitats as refuge areas. NMFS trawl surveys suggest that older juveniles occur in shallower areas than adults.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal or temporary effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	MT (Minimal or temporary effect)

For the general distribution for BSAI northern rockfish, the potential reduction in living structure and non-living structure along the EBS slope is projected to be 12 and 4 percent, respectively. However, the EBS slope accounts for only 2 percent of the habitat of northern rockfish in Alaskan waters. In the AI deep areas (200 to 1,000 m), which account for 19 percent of the northern rockfish habitat, the potential reductions in living structure and non-living structure are projected to be 6 and 4 percent, respectively. In the AI shallow areas, which account for 30 percent of the northern rockfish habitat, the potential reduction in living structure and non-living structure is projected to be 10 and 1 percent, respectively. Although northern rockfish may eat some epifauna prey, such as crabs and shrimp, the largest component of their diet is euphausids and thus any percent reductions in epifauna prey would be expected to have a minimal and temporary effect on their feeding. A reduction in living structure and non-living structure would also be expected to have a minimal and temporary effect on spawning/breeding and feeding due to the lack of strong associations of these benthic features with adult northern rockfish. A reduction in living structure and non-living structure may affect growth to maturity due to a reduction of refuge habitat for juveniles. Although the extent to which northern rockfish use rocky habitats as refuges is uncertain, the percent reductions of these habitat features is generally small and would be expected to have minimal and temporary effects.

B.3.3.20 Northern Rockfish (GOA)

Habitat Connections

Northern rockfish (*Sebastes polyspinis*) in the northeast Pacific Ocean range from the EBS, throughout the AI and the GOA, to Northernmost British Columbia (Allen and Smith 1988). Little is known about the biology and life history of northern rockfish.

Spawning/Breeding
Like other members of the genus *Sebastes*, northern rockfish bear live young, and birth is believed to occur in the early spring. There is no information on larval and early juvenile biology or habitat. Consequently, there is no evidence (e.g., publications, field studies, etc.) that links habitat features with northern rockfish accomplishing the spawning/breeding process.

Feeding
Northern rockfish are generally planktivorous (feed on plankton) with euphausiids being the predominant prey item in both the GOA and the AI (Yang 1993, 1996, Yang and Nelson 2000). Large offshore euphausiids are not directly associated with the bottom, but rather are thought to be advected onshore near bottom at the upstream ends of underwater canyons where they become easy prey for planktivorous fishes (Brodeur 2001). Copepods, hermit crabs, and shrimp have also been noted as prey items in much smaller quantities (Yang 1993, 1996). There is no evidence that links habitat features with northern rockfish accomplishing the feeding process.

Growth to Maturity
There is no information on larval and early juvenile biology or habitat of northern rockfish. Little information is available on the habitat of juvenile northern rockfish. Studies using submersibles have indicated that several species of rockfish appear to use rocky, shallower habitats during their juvenile stage (Carlson and Straty 1981, Kreiger 1993). Although these studies did not specifically observe northern rockfish, it is reasonable to suspect that juvenile northern rockfish also use these shallower habitats as refuge areas. Length frequencies of northern rockfish captured in NMFS bottom trawl surveys and observed in commercial fishery bottom trawl catches indicate that older juveniles are found on the continental shelf, generally at locations inshore of the adult habitat (pers. comm. Dave Clausen).

Trawl surveys and commercial fishing data indicate that the preferred habitat of adult northern rockfish in the GOA is on relatively shallow rises or banks on the outer continental shelf at depths of ~75 to 150 m (Clausen and Heifetz 2003). Northern rockfish appear to be associated with relatively rough bottoms on these banks, and they are mostly demersal in their distribution (pers. comm. Dave Clausen[1]). Observations from a submersible in the AI have also identified adult northern rockfish associated with boulders and sponges in mixed sand/gravel on the shallow (less than 200 m) slope. Consequently there is evidence that links the living and non-living structure with northern rockfish accomplishing the growth to maturity process during the juvenile and adult stages. Based upon the depth distributions and substrate types described above, these links most likely occur in shallow (0 to 100 m), and deeper shelf area (100 to 300 m) habitat types over soft and hard substrates and are included as such in the GOA northern rockfish connections table (Table B.3-1).

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

For the general distribution of GOA northern rockfish is designated as those areas where 95 percent the potential reductions in living and non-living structure along the GOA shallow shelf (less than 100 m) are projected to be 6 and 1 percent, respectively. In the GOA deep shelf (100 to 300 m), the potential reduction in living and non-living structure is projected to be 10 and 1 percent, respectively. Although northern rockfish may eat some epifauna prey, such as crabs and shrimp, the largest component of their diet is euphausids and thus the percent reductions in epifauna prey would not be expected to have a significant impact on their feeding. A reduction in living and non-living structure would be expected to have no effect on spawning/breeding and feeding due to the lack of strong associations of these benthic features with GOA northern rockfish. A reduction in living and non-living structure could plausibly jeopardize growth to maturity due to a reduction of refuge habitat for juvenile GOA northern rockfish. However, as determined in the Draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the northern rockfish to maintain themselves at or above their respective MSSTs. Therefore, the effects of the reductions in habitat features are either minimal or temporary in terms of the northern rockfish stocks' abilities to maintain themselves at or above MSST. There is also no evidence to suggest that the potential reductions in living and non-living structure affect growth and survival to maturity sufficiently to affect the ability of GOA northern rockfish to fulfill its role in a healthy ecosystem.

B.3.3.21 Pelagic Shelf Rockfish (GOA)

The pelagic shelf rockfish management group in the GOA comprises three species: dusky rockfish (*Sebastes ciliatus*), yellowtail rockfish (*S. flavidus*) and widow rockfish (*S. entomelas*). As discussed in Section 3.2.1.1.10.5, dusky rockfish is in the process of being taxonomically divided into two species: a light-colored form and a dark-colored form. Light dusky rockfish is much more abundant in Alaska than the other three species, and it supports a valuable trawl fishery in the GOA. Because of the abundance and commercial importance of light dusky rockfish in the GOA, this section will focus exclusively on the EFH for this species. They are, by far, the dominant species in this group, both in terms of biomass and harvest. Their habitat requirements are not expected to be so different from other species in this group to require separate analysis.

Habitat Connections

Habitat preferences for the life stages of light dusky rockfish are either unknown or very poorly known (Table B.3-1). Similar to all other species of *Sebastes*, the egg stage is completed inside the female. The larval stage is pelagic, but larval studies are hindered by the fact that the larvae at present can only be positively identified by genetic analysis, which is both expensive and labor-intensive. Post-larval light dusky rockfish have not been identified; however, the post-larval stage for other *Sebastes* is pelagic, so it is also likely to be pelagic for light dusky rockfish. The habitat of young juveniles is completely unknown. At some point they are assumed to migrate to the bottom and take up a demersal existence, but virtually no juveniles less than 25 cm fork length have been caught in bottom trawl surveys (Clausen et al. 2002) or with other sampling gear. Older juveniles have been taken only infrequently in the trawl surveys, but when caught are often found at more inshore and shallower locations that adults. For this reason, they are noted in Table B.3-1 as occurring on both the shallow and deep shelf, whereas adults are listed for only the deep shelf. Adult Light dusky rockfish are concentrated on offshore banks and near gullies on the outer continental shelf at depths of 100 to 200 m (Reuter 1999), and therefore are assigned to the deeper shelf area in Table B.3-1. Anecdotal evidence from fishermen and from biologists on the trawl surveys suggests that light dusky rockfish are often caught in association with a hard, rocky bottom on these banks or gullies. Also, during submersible dives on the outer shelf of the eastern GOA, light dusky rockfish were observed in association with rocky habitats and in areas with extensive sponge beds where adults were seen resting in large vase sponges. Another study using a submersible in the eastern GOA observed small Light dusky rockfish associated with *Primnoa* spp. corals (Krieger and Wing 2002). Hence, Table B.3-1 shows both adults and older juveniles associated with living and non-living structure, and older juveniles associated with corals.

Spawning/Breeding
There is no information on reproductive behavior for light dusky rockfish, except that parturition is believed to occur in the spring, based on observations of ripe females sampled on a research cruise in April 2001 in the central GOA. Because of this lack of knowledge, the effects of fishing on the habitat required for reproduction of light dusky rockfish are unknown.

Feeding
The major prey of adult light dusky rockfish appears to be euphausiids, based on the limited food information available for this species (Yang 1993). As euphausiids are pelagic rather than benthic in their distribution and are too small to be retained by any fishing gear, fishing probably has a minimal or temporary effect on the availability of prey to adult light dusky rockfish.

Growth to Maturity
As was previously discussed, habitat requirements for the various life stages of light dusky rockfish are mostly unknown. Younger juveniles (less than 25 cm fork length) are almost never caught on any fishing gear, so it is likely that fishing does not occur (and thus has no direct effect) on whatever habitat they do occupy. However, older juveniles and adults have been observed in association with corals and sponges (Krieger and Wing 2002), and both life stages may prefer the rocky substrate inhabited by such epifauna. Although the importance of these associations is uncertain, bottom trawling is known to damage such living substrates and could have a negative impact on stocks of this species. Taking into consideration all these factors, a rating of “unknown” is given to the “growth to maturity” and light dusky rockfish.

Evaluation of Effects

Issue	**Evaluation**
Spawning/breeding	U (Unknown effect)
Feeding	MT (Minimal or temporary effect)
Growth to maturity	U (Unknown effect)

The effects of fishing on the habitat of light dusky rockfish are either unknown or negligible. However, there is some information to suggest that bottom trawling may have a negative impact on the benthic habitat, especially corals and sponges, which are used by juvenile and adult fish.

B.3.3.22 Thornyhead Rockfish (GOA)

Habitat Connections

Spawning/Breeding
Thornyheads spawn gelatinous pelagic egg masses. See Section 3.2.1.2.11 for further discussion and references.

Feeding
The adults feed mainly on epibenthic shrimp in the GOA; other prey includes small fish, benthic amphipods, and other benthic invertebrates and euphausiids. See Section 3.2.1.2.11 for further discussion and references.

Growth to Maturity
Larvae are pelagic for up to 15 months. Juveniles habits are generally unknown. Adults are demersal, and are found in deep waters between 200 to 1,000 m. There is some evidence from studies of California and Oregon that younger individuals are found in shallower waters 200 to 600 m deep and that larger, older fish are found in deeper waters between 600 to 1,000 m. See Section 3.2.1.2.11 for further discussion and references.

Evaluation of Effects

Issue	Evaluation
Spawning/breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

GOA thornyhead eggs are presumed to be associated with pelagic habitats based on observations off the US West Coast. GOA juveniles and adults are also associated with benthic habitats; specifically, on the deep shelf and slope in any type of non-living substrate, but they may prefer hard, non-living substrate according to limited studies in the eastern GOA. Overall, the GOA deep shelf and slope habitats comprise 33 and 22 percent, respectively, of the area designated as the Thornyhead concentration distribution within the GOA (Table B.3-3). Of this 33 and 22 percent, 1 percent of the non-living substrate within the deep shelf and slope GOA habitat is projected to be reduced under status quo (Table B.3-3). It is assumed that this would have a negligible impact. Therefore the ratings for the effects of spawning/breeding and growth to maturity for GOA thornyheads are "no effect." The adults feed mainly on epibenthic shrimp and other benthic organisms which are included in epifauna and infauna features which are projected to be reduced by 1 percent in each habitat. It is assumed that the 1 percent reduction of epifauna and infauna within the GOA shallow and deep shelf habitats occupied by thornyheads would not have an impact and the rating for feeding is also "no effect."

B.3.3.23 Other Rockfish Species (BSAI)

Light Dusky Rockfish

Habitat Connections, Evaluation of Effects

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

No studies have been conducted in the EBS or AI to suggest that fishing activities have an effect on the habitat of light dusky rockfish. The adults of this species are thought to occur mainly in the middle and lower portions of the water column over areas of cobble, rock and gravel along the outer continental shelf and upper slope region, thus any adverse effects to this habitat type may influence the health of the light dusky rockfish population.

BSAI Thornyhead Rockfish

Habitat Connections, Evaluation of Effects

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—No studies have been conducted in the EBS or AI to suggest that fishing activities have an effect on the habitat of thornyhead rockfish. The juveniles and adults of this species are thought to occur over mud, sand, rock, cobble, and gravel substrate along the middle and outer continental shelf to the upper and lower slope of the EBS and AI, thus any adverse effects to this habitat type may influence the health of the thornyhead rockfish population.

B.3.3.24 Other Species

B.3.3.24.1 BSAI sharks (sleeper sharks and salmon sharks)

Habitat Connections, Evaluation of Effects

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the EBS or AI to determine whether fishing activities have an effect on the habitat of sleeper sharks or salmon sharks. Sleeper sharks are thought to occur mainly in the middle and lower portions of the water column along the outer continental shelf and upper slope region, thus any adverse effects to this habitat type may influence the health of the sleeper shark population. Salmon sharks are thought to occur in pelagic waters along the outer continental shelf and upper slope region of the EBS, thus any adverse effects to this habitat type, including disruption or removal of pelagic prey by fisheries, may influence the health of the salmon shark population.

B.3.3.24.2 GOA sharks (dogfish, sleeper sharks, and salmon sharks)

Habitat Connections, Evaluation of Effects

Issue	**Evaluation**
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the GOA to determine whether fishing activities have an effect on the habitat of dogfish, sleeper sharks, or salmon sharks. Dogfish are thought to occur in the middle and lower portions of the water column and appear to concentrate in gullies along the continental shelf in the GOA. Sleeper sharks are thought to occur mainly in the middle and lower portions of the water column along the outer continental shelf and upper slope region, as well as in similar depths in Shelikof Strait and other gully habitats. Salmon sharks are pelagic throughout the GOA and appear to concentrate in Prince William Sound as well as in Shelikof Strait. Thus any adverse affects to these habitat types may influence the health of GOA shark populations.

B.3.3.24.3 BSAI Skates (between 8 and 15 species in the genus *Bathyraja*)

Habitat Connections, Evaluation of Effects

Issue	**Evaluation**
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the EBS or AI to determine whether fishing activities have an effect on the habitat of skates. Skates are benthic dwellers. The Alaska skate dominates the skate complex biomass in the EBS and is distributed mainly on the upper continental shelf. The diversity of the group increases with depth along the outer continental shelf and slope, with several new species likely to be described in the near future. Therefore, any adverse affects to the shallow shelf habitat may influence the health of the Alaska skate populations, while any adverse affects to outer continental shelf and slope habitats may influence the health of multiple species of skates.

B.3.3.24.4 GOA skates (two Raja species, Big and longnose skate, and 8-15 Bathyraja species)

Habitat Connections, Evaluation of Effects

Issue	**Evaluation**
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the GOA to determine whether fishing activities have an effect on the habitat of skates. Skates are benthic dwellers. The big skate, a new commercial species in the GOA, comprises just under half of the skate complex biomass in the GOA and is distributed mainly on the upper continental shelf. However, other skate species are found throughout that habitat as well. The diversity of the group increases with depth in the gullies within the continental shelf and along the outer continental shelf and slope. Therefore, any adverse affects to the shallow shelf habitat may influence the health of the big skate populations as well as other skate species, while any adverse affects to outer continental shelf and slope habitats may influence the health of multiple species of skates.

B.3.3.24.5 BSAI sculpins (over 60 species identified in BSAI trawl surveys)

Habitat Connections, Evaluation of Effects

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the EBS or AI to determine whether fishing activities have an effect on the habitat of sculpins. Sculpins are benthic dwellers. Some sculpin species guard their eggs, and at least one species, the bigmouth sculpin, lays its eggs in vase sponges in the AI, although it is not known whether a particular type of sponge, or sponges in general, are essential to reproductive success. There are so many diverse species in this category that almost all benthic areas in the EBS and AI are likely to be inhabited by at least one sculpin species. Therefore, any adverse affects to habitat may influence the health of species in the sculpin complex.

B.3.3.24.6 GOA sculpins (48 species identified in GOA trawl surveys)

Habitat Connections, Evaluation of Effects

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the GOA to determine whether fishing activities have an effect on the habitat of sculpins. Sculpins are benthic dwellers. Some sculpin species guard their eggs, and at least one species, the bigmouth sculpin, lays its eggs in vase sponges, although it is not known whether a particular type of sponge, or sponges in general, are essential to reproductive success. There are so many diverse species in this category that almost all benthic areas in the GOA are likely to be inhabited by at least one sculpin species. Therefore, any adverse affects to habitat may influence the health of species in the sculpin complex.

B.3.3.24.7 BSAI squids (5 or more species)

Habitat Connections, Evaluation of Effects

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the EBS or AI to determine whether fishing activities have an effect on the habitat of squid. Squid are thought to occur in pelagic waters along the outer continental shelf and upper slope region of the EBS and AI, and concentrate over submarine canyons, thus any adverse effects to this habitat may influence the health of the squid populations.

B.3 3.24.8 GOA Squid (10 or more species)

Habitat Connections, Evaluation of Effects

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the GOA to determine whether fishing activities have an effect on the habitat of squid. Squid are thought to occur in pelagic waters along the gullies within the continental shelf and the outer continental shelf and upper slope region of the GOA and concentrate over submarine canyons, thus any adverse effects to this habitat may influence the health of the squid populations.

B.3.3.24.9 BSAI octopi (5 or more species)

Habitat Connections, Evaluation of Effects

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the EBS or AI to determine whether fishing activities have an effect on the habitat of octopi. Octopi occupy all types of benthic habitats extending from very shallow subtidal areas to deep slope habitats, thus any adverse effects to this habitat may influence the health of octopus populations. Knowledge of octopi distributions are insufficient to allow comparison with fishing effects.

B.3.3.24.10 GOA octopi (5 or more species)

Habitat Connections, Evaluation of Effects

Issue	Evaluation
Spawning/breeding	U (Unknown effect)
Feeding	U (Unknown effect)
Growth to maturity	U (Unknown effect)

Summary of Effects—Essential habitat requirements for species in this category are unknown. No studies have been conducted in the GOA to determine whether fishing activities have an effect on the habitat of octopi. Octopi occupy all types of benthic habitats extending from very shallow subtidal areas to deep slope habitats, thus any adverse effects to this habitat may influence the health of octopus populations. Knowledge of octopi distributions are insufficient to allow comparison with fishing effects.

B.3.4 Effects of Fishing on Essential Fish Habitat of Forage Species

The Forage Species category was created by Amendments 36 and 39 to the BSAI and GOA FMP. This category includes eight families of fish (Osmeridae, Myctophidae, Bathylagidae, Ammodytidae, Trichodontidae, Pholidae, Stichaeidae, and Gonostomatidae) and one order of crustaceans (Euphausiacea). The aforementioned amendments prohibit the directed fishery of any forage species. The species included in this category have diverse life histories and it is impractical to analyze the group as a whole. Therefore, for the purpose of this document each family and order will be analyzed separately.

B.3.4.1 Family Osmeridae

Habitat Connections

Spawning/Breeding
Most of the Alaskan species of Osmerids (or smelt) spawn on beaches, rivers or estuaries. There is little to no fishing pressure in the habitat needed for spawning/breeding. Hence, the effects of fishing are anticipated to have no impact on essential spawning, nursery or settlement habitat.

Feeding
Adult smelt feed on pelagic zooplankton. The majority of the smelt diet is composed of euphausiids and copepods, which are not likely to be affected by fishing.

Growth to Maturity
Osmerids have pelagic larval, juvenile and adult life stages. During these stages there is no evidence that survival of smelt is dependent on habitat that is affected by fishing.

Evaluation of Effects

Issue	Evaluation
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Most of the Alaskan species of smelt spawn on beaches, rivers, or in estuaries. Certain species of smelt, such as capelin, have been shown to have an affinity towards spawning grounds with specific substrate grain size (coarse sand or fine gravel). Therefore, non-living substrate is assumed to be very important for spawning/breeding. However, smelt spawning areas do not overlap with areas of intensive fishing. There is little to no fishing pressure in the nearshore environment needed by these species. Hence, the effects of fishing are anticipated to have little impact on the stock. The rating for the effects of fishing on Spawning/Breeding of smelt is "MT."

Juvenile and adult smelt feed primarily on neritic plankton. There is little evidence that survival or prey availability of smelt is dependent on habitat that is disturbed by fishing. Therefore, the effects of fishing on the feeding and growth to maturity of smelt is rated "MT."

B.3.4.2 Family Myctophidae

Habitat Connections

Spawning/Breeding
Myctophids (or lanternfish) are small bathypelagic species of fish. Myctophids are broadcast spawners and their eggs are pelagic. Hence, the effects of fishing are anticipated to have little impact on essential spawning, nursery or settlement habitat.

Feeding
Adult Myctophids feed on pelagic zooplankton. Myctophid diet is composed largely of euphausiids and copepods, which are not species likely to be affected by fishing.

Growth to Maturity
Myctophids have pelagic larval, juvenile and adult life stages. During these stages there is no evidence that survival of Myctophids is dependent on habitat that is affected by fishing.

Evaluation of Effects

Issue	Evaluation
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Myctophids are pelagic throughout all life history stages. There is little evidence that Myctophid survival is dependent on habitat affected by fishing. Myctophids are broadcast spawners with pelagic eggs. Juvenile and adult Myctophids prey on neritic zooplankton and do not require physical structure for protection. Therefore, the effects of fishing on the spawning/breeding, feeding and growth to maturity of Myctophids is rated "MT."

B.3.4.3 Family Ammodytidae

Habitat Connections

Spawning/Breeding
Pacific sand lance (*Ammodytes hexapterus*) spawn on sand in shallow water. There is little to no fishing pressure in the nearshore habitat needed for spawning/breeding. Hence, the effects of fishing are anticipated to have no impact on essential spawning, nursery or settlement habitat.

Feeding
Adult sand lance feed on pelagic zooplankton. The majority of the sand lance diet is composed of copepods, which are not likely to be affected by fishing.

Growth to Maturity
Pacific sand lance have pelagic larval, juvenile, and adult life stages. During these stages there is no evidence that survival of sand lance is dependent on habitat that is affected by fishing.

Evaluation of Effects

Issue	Evaluation
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

The sole member of family Ammodytidae found in Alaska is the Pacific sand lance (*Ammodytes hexapterus*). Sand lance have been shown to have an affinity towards spawning grounds with specific substrate grain size (coarse sand). Therefore, non-living substrate is assumed to be very important for spawning/breeding. However, smelt spawning areas do not overlap with known areas of intensive fishing. There is little to no fishing pressure in the nearshore habitat needed by these species. Hence, the effects of fishing on the EFH of sand lance is rated "MT."

Juvenile and adult sand lance feed primarily on copepods. There is little evidence that survival or prey availability of sand lance is dependent on habitat disturbed by fishing. Therefore, the effects of fishing on the feeding and growth to maturity of smelt is rated "MT."

B.3.4.4 Family Trichodontidae

Habitat Connections

Spawning/Breeding
Pacific sandfish (*Trichodon trichodon*) lay demersal adhesive egg masses in rocky intertidal areas. There is little to no fishing pressure in the nearshore habitat needed for spawning/breeding. Hence, the effects of fishing are anticipated to have no impact on essential spawning, nursery or settlement habitat.

Feeding
Pacific sandfish are ambush predators that lay in wait for prey buried under the sand. They have been shown to consume some epifauna prey but greater than 95 percent of their diet consists of small fish. It is unknown how these prey species are affected by fishing.

Growth to Maturity
Pacific sandfish larvae are pelagic, but juveniles and adults are demersal. Little is known about sandfish distribution in the BSAI and GOA. The effect of fishing on the survival of Pacific sandfish is unknown.

Evaluation of Effects

Issue	Evaluation
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	U (Unknown)
Growth to maturity	U (Unknown)

Two members of the family Trichodontidae are found in the BSAI and GOA the Sailfin sandfish (*Arctoscopus japonicus*) and the Pacific sandfish (*Trichodon trichodon*). However, the Sailfin sandfish is rarely encountered in Alaskan waters. For the purposes of this document attention will be focused on the Pacific sandfish.

Pacific sandfish lay demersal adhesive egg masses in rocky intertidal areas. The presence of the proper non-living substrate is important for the spawning/breeding of sandfish. However, there is little overlap of the spawning areas with known areas of intensive fishing. Hence, the effects of fishing on spawning/breeding of sandfish is rated "MT."

Pacific sandfish are ambush predators that lay in wait for prey buried under the sand. They have been shown to consume some epifauna prey but greater than 95 percent of their diet consisted of small fish. It is unknown (U) how these prey species are affected by fishing.

Pacific sandfish larvae are pelagic but juveniles and adults are demersal. Little is known about sandfish distribution in the BSAI and GOA. The effect of fishing on the survival of Pacific sandfish is unknown due to lack of data.

B.3.4.5 Family Pholidae

Habitat Connections

Spawning/Breeding
There are several species of Pholids (or gunnels) found in Alaskan waters. Most species of gunnels reside and breed in the shallow, nearshore habitat where there is little to no fishing effort. Hence, the effects of fishing are anticipated to have no impact on essential spawning, nursery, or settlement habitat.

Feeding
The diet of gunnels has been shown to rely heavily on epifauna and infauna prey. However, as stated above, there is little fishing in the shallow waters utilized by these species. For that reason, the effects of fishing are anticipated to have no impact on prey availability.

Growth to Maturity
There is little to no fishing pressure in the shallow, nearshore environment occupied by Pholids. Consequently, the effects of fishing are anticipated to have no impact on the survival of fish to maturity.

Evaluation of Effects

Issue	Evaluation
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

There are several species of Pholids (or gunnels) found in Alaskan waters. Most species of gunnels reside, feed and breed in the shallow, nearshore habitat where there is little to no fishing effort. Due to the lack of fishing pressure in the environs used by Pholids the effects of fishing on the spawning/breeding, feeding, and growth to maturity are all rated "MT."

B.3.4.6 Family Stichaeidae

Habitat Connections

Spawning/Breeding
There are many species of Stichaeids (or pricklebacks) found in Alaskan waters. Most species of pricklebacks reside and breed in the shallow, nearshore habitat where there is little to no fishing effort. Hence, the effects of fishing are anticipated to have no impact on essential spawning, nursery, or settlement habitat.

Feeding
The diet of pricklebacks has been shown to rely heavily on epifauna and infauna prey. However, as stated above, there is little fishing in the shallow waters used by these species. For that reason, the effects of fishing are anticipated to have no impact on prey availability.

Growth to Maturity
There is little to no fishing pressure in the shallow, nearshore environment occupied by Stichaeids. Consequently, the effects of fishing are anticipated to have no impact on the survival of fish to maturity.

Evaluation of Effects

Issue	Evaluation
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Due to the lack of fishing pressure in the environs used by Stichaeids the effects of fishing on the spawning/breeding, feeding, and growth to maturity are all rated "MT."

B.3.4.7 Family Gonostomatidae

Habitat Connections

Spawning/Breeding
Gonostomatids (or bristlemouths) are small bathypelagic species of fish. Gonostomatids are broadcast spawners and their eggs are pelagic. Hence, the effects of fishing are anticipated to have little impact on essential spawning, nursery, or settlement habitat.

Feeding
Adult Gonostomatids feed on pelagic zooplankton (mostly copepods). Gonostomatid prey species are not likely to be affected by fishing.

Growth to Maturity
Bathylagids have pelagic larval, juvenile and adult life stages. During these stages there is no evidence that survival of Bathylagids is dependent on habitat that is affected by fishing.

Evaluation of Effects

Issue	Evaluation
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Gonostomatids are pelagic throughout all life history stages. There is little evidence that Gonostomatid survival is dependent on habitat that is affected by fishing. Gonostomatids are broadcast spawners with pelagic eggs. Juvenile and adult Gonostomatids prey on neritic zooplankton and do not require physical structure for protection. Therefore, the effects of fishing on the spawning/breeding, feeding, and growth to maturity of Gonostomatids is rated "MT."

B.3.4.8 Order Euphausiacea

Habitat Connections

Spawning/Breeding
Euphausiids are broadcast spawners and their eggs are pelagic. Hence, the effects of fishing are anticipated to have little impact on essential spawning, nursery, or settlement habitat.

Feeding
Euphausiids feed on phytoplankton and zooplankton. Euphausiid prey species are not likely to be affected by fishing.

Growth to Maturity
Euphausiids have pelagic egg, larval and adult life stages. During these stages there is no evidence that survival of euphausiids is dependent on habitat affected by fishing.

Evaluation of Effects

Issue	Evaluation
Spawning/Breeding	MT (Minimal, temporary, or no effect)
Feeding	MT (Minimal, temporary, or no effect)
Growth to maturity	MT (Minimal, temporary, or no effect)

Euphausiids (or krill) are small, shrimp-like crustaceans which, along with copepods, make up the base of the food web in the BSAI and GOA. Euphausiids are pelagic throughout their entire life cycle and do not have a strong link to habitat that is affected by fishing. Euphausiids do not require habitat that is disrupted by fishing for spawning/breeding, feeding, or growth to maturity. Therefore, the effects of fishing for Euphausiids is "MT."

B.4 Conclusions

B.4.1 Species Evaluations

Evaluations were completed for 26 managed species (or species groups) and 8 forage species (Table B.4-1). Detailed texts are in Sections B.3.3 to B.3.5. None of the life history processes of any species were expected to be affected in a way that was more than minimal and not temporary in terms of its effect on species welfare. Reasons for minimal or temporary ratings were predominantly either lack of a connection to affected features or findings from stock analyses that current fishing practices (including effects on habitat) do not jeapordize the ability of the stock to remain above MSST. Other evaluations indicated that, even though a connection could exist between a feature and a life-history process, the expected feature reductions were considered too small to make effects at the population level likely. There were also cases where the effects did not overlap significantly with the distribution of the species.

About one-third of the ratings were U (Unknown effect). Most of unknown ratings were for species that have received relatively little study and hence their life-history needs and population status are poorly known. As species that support significant fisheries have been studied more, most species with unknown ratings support small or no fisheries. In some cases, associations between the habitat features and life history processes were indicated, but the evaluator did not have information to assess whether the linkage and the amount of feature reduction would affect species welfare.

Even for well studied species, the knowledge to confidently trace use of habitat features to spawning, breeding, feeding and growth to maturity to population level effects is not yet available. Several evaluators specifically noted uncertainty regarding the effect of particular noted linkages and some urged caution. Most of these situations involved potential linkages between the growth-to-maturity of rockfish and Atka mackerel and habitat structure.

B.4.2 General Effects on Fish Habitat

While this evaluation identified no specific instances of adverse effects on EFH that were more than minimal and not temporary, the large number of unknown ratings and expressions of concern make it prudent to look for more general patterns across all of the species and habitat features (Table B.4-2).

Specific areas with high fishing effort and hence high LEIs were identified in the effects-of-fishing analysis. These included two large areas of the EBS, one North of Unimak Island and Unimak Pass and the other between the Pribilof Islands and Bristol Bay. Both of these areas have continued to be highly productive fishing grounds through decades of intensive fishing. While that may initially seem at odds with the LEI results, it is actually consistent with the evaluation that the habitat features affected by fishing are either not those important to the species fished in those areas, or are not being affected in a way that limits species welfare.

Fishing concentrations in other areas were smaller, but made up higher proportions of the GOA and EBS slopes. The largest effect rates were on living structure, including coral. The high reliance on limited areas for fishing production and their high estimated LEIs make it prudent to obtain better knowledge of what processes occur in those locations.

Table B.3-1 shows the habitat connections identified for each life stage of managed species and species groups. Each row represents a species life-stage and each column one of the habitat types from the fishing-effects analysis. At their intersections evaluators entered letters representing each of the habitat features (prey or structure classes) used by that life stage in that habitat. Most species of groundfish have pelagic larval and egg stages. Only one species, Atka mackerel, had a connection with a benthic habitat feature for its egg or larval stages. A combined tally at the bottom of the table notes how many species/life-stages were identified for each habitat feature in each habitat. Prey features represented about twice as many connections as structure features. The habitat feature/type combinations that had LEIs above 5 percent, outlined in the table, tended to have few connections. The most was for living structure on the GOA deep shelf (6), which had the lowest LEI of the group (6.2 percent). Connections with the highlighted blocks mostly involved rockfish species, with a few from Atka mackerel and blue king crab.

Cropping and summing effects on habitat features by distributions of the adults of each species (Table B.3-3) depicted how the fishing effects overlapped in the locations where each species is present. The general distribution values related to the broader areas occupied, while the concentration values related to areas of higher abundance. Concentration LEIs were generally higher than the estimates based on general distribution, since adult species concentrations determine where fisheries operate. It is unfortunate that distributions were not available for juveniles, since connections to the habitat feature with the highest LEIs (living structure) mostly involved the growth to maturity process. Characterizing juvenile distributions should be a high priority for future research.

Reductions across adult species distributions for the living structure were mostly between 10 and 17 percent. Higher values occurred for red king crab (29 percent for both coverages) and Atka mackerel (18 and 26 percent). The king crab evaluator noted that the distribution of juveniles was mostly outside of the affected areas. The evaluator for Atka mackerel emphasized use of non-living substrates by that species. Prey class effects by species distributions were all at or below 5 percent. In combination with negligible effects on habitat of forage species (Section B.3.5), this indicates that effects on availability of prey were minimal.

While LEIs for hard corals are subject to the limitations mentioned in Section B.2.6, they had the highest LEIs when considered by species distributions. Intersections where meaningful effects are most likely to occur are those between areas where hard corals are prevalent and species for which a significant portion of their distribution occurs in the same areas, including populations of golden king crab, Atka mackerel, sablefish and the rockfish species. Coral LEIs at these points ranged from 23 to 59 percent. While few evaluators cited coral as specifically linked to life history functions, in some areas it may be an important component of the living structure that was potentially linked to growth to maturity for some of these species. Because of its very slow recovery, corals warrant particular consideration for protection and for the development of improved knowledge of its habitat functions and distribution.

B.5 Cumulative Effects of Fishing and Non-fishing Activities on EFH

This section discusses the cumulative effects of fishing and non-fishing activities on EFH. As identified in Section 4.4, historical fishing practices may have had effects on EFH that have led to declining trends in some of the criteria examined (Table ES-1). As described in earlier sections of Appendix B (Table B.4-2), the effects of current fishing activities on EFH are classified as minimal and temporary or unknown. Table B.4-2 identifies the rationale for the rating under each fishery.

A complete review of the effects of non-fishing activities on EFH is found in Appendix G and Table 3.4-37 of this EIS. Table 3.4-37 provides a summary of the detailed text descriptions found in Appendix G. The table identifies 31 non-fishing activities for which potential effects are described in Appendix G. However, the magnitude of these effects cannot currently be quantified with available information. Of the 31 activities, most are described as likely having less than substantial potential effects on EFH. Some of these activities such as urban/suburban development, road building and maintenance including the placement of fill material, vessel operations/transportation/navigation, silviculture including LTFs, and point source discharge, may have potential cumulative impacts due to the additive and chronic nature of these activities. NMFS does not have regulatory authority over non-fishing activities but frequently provides recommendations to other agencies to avoid, minimize, or otherwise mitigate the effects of these activities.

The individual effects of fishing and each activity identified in the analysis of non-fishing activities may not significantly affect the function EFH. However, the synergistic effect of the combination of all of these activities may be a cause for concern. Unfortunately, available information is not sufficient to assess how the cumulative effects of fishing and non-fishing activities influence the function of EFH on an ecosystem or watershed scale. The magnitude of the combined effect of all of these activities cannot be quantified, so the level of concern is not known at this point.

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Table B.2-1. Effects of I (=q*f) and Rho Parameters on Estimates of Long-term Habitat Reduction

Habitat Effect (Percent Reduction)										
Recovery	Avg. Effect Rate (I)									Rec. Time
Rate = D	0.001	0.01	0.04	0.06	0.08	0.1	0.15	0.2	0.3	R = 1/D
0.01	9	50	81	86	90	92	95	96	98	100
0.02	5	34	68	76	81	85	90	92	95	50
0.04	2	20	51	61	68	73	81	86	91	25
0.1	1	9	29	39	46	52	64	71	80	10
0.2	0	5	17	24	30	36	47	55	67	5
0.4	0	2	9	14	18	22	30	38	50	3
1	0	1	4	6	8	10	15	20	29	1
2	0	1	2	3	4	5	8	11	17	1
4	0	0	1	2	2	3	4	6	9	0

Table B.2-2. A Summary of the Fishing Effects Analysis Process, Including Input Data Matricies, Calculation Steps, and Output Matrices

Indices
i - block
g - fishery
j - feature
k - habitat

Input Data
Fishing Intensity matrix (f_{ig}) - proportion of each block's area swept by the gear used by each fishery in an average year.
Sensitivity matrix ($q_{g(j\bullet k)}$)- proportion by which each feature's function in each habitat is reduced by one pass of the gear used in each fishery.
Recovery matrix ($\rho_{(j\bullet k)}$) - The recovery rate for the function of each habitat feature within each habitat.
Block Categorization matrix (C_{ik}) - The area (sq. km) of each block estimated to be within each habitat.
Area vector (A_k) - The area (sq. km) covered by each habitat.

Analysis Steps
1. Multiply effort matrix (f_{ig}) and sensitivity matrix ($q_{g(j\bullet k)}$) to get effect rate matrix ($I_{i\,(j\bullet k)}$)

$$I_{i\,(j\bullet k)} = \sum_g (q_{g(j\bullet k)} * f_{ig})$$

2. Apply effect equation to effect rate matrix ($I_{i\,(j\bullet k)}$) and recovery vector ($\rho_{(j\bullet k)}$) to get effect matrix ($Heq_{\,i\,(j\bullet k)}$)

$$Heq_{\,i\,(j\bullet k)} = \rho_{(j\bullet k)} S/(I_{i\,(j\bullet k)} + \rho_{(j\bullet k)} S), \qquad \text{where } S=e^{-Ii\,(j\bullet k)}$$

3. Multiply 1 minus each cell of the effect ($Heq_{\,i\,(j\bullet k)}$) matrix by the corresponding cell of the block categorization matrix (C_{ik}) to get the proportional decrease of that feature in that habitat type occurring in that block , long-term effect index($LEI_{\,i\,(j\bullet k)}$)

$$LEI_{\,i\,(j\bullet k)} = (1 - Heq_{\,i\,(j\bullet k)})*C_{ik}$$

4. Sum $E_{\,i\,(j\bullet k\bullet d)}$ matrix across blocks (i) and divide by the total area of each habitat type ($A_{\,k}$) to get the total proportional decrease of that feature in that habitat type ($LEI_{\,(j\bullet k)}$)

$$LEI_{\,(j\bullet k)} = \sum_i LEI_{\,i\,(j\bullet k)}/A_k$$

Output - Long-term Effect Index ($LEI_{\,i\,(j\bullet k)}$, $LEI_{\,(j\bullet k)}$)
The proportion by which habitat is reduced (adverse effect) for each habitat feature for each block and across each habitat type if recent fishery intensity and distribution were continued at current levels to equilibrium.

Table B.2-3. Fisheries Considered in the Analysis of Fishing Effects on Essential Fish Habitat

Target	Gear	Code
Bering Sea		
Scallop*	Dredge	N/A
Red King Crab*	Pot	N/A
Tanner Crab*	Pot	N/A
Snow Crab*	Pot	N/A
Flathead Sole and Other Flatfish	Bottom Trawl	FHO_TR
Cod	Bottom Trawl	PC_TR
Pollock	Bottom Trawl	PK_TR
Rock Sole	Bottom Trawl	RK_TR
Rockfish	Bottom Trawl	RR_TR
Sablefish / Turbot	Bottom Trawl	ST_TR
Yellowfin sole	Bottom Trawl	YF_TR
Pollock	Pelagic Trawl	PK_PTR
Cod	Longline	PC_LL
Sablefish / Turbot	Longline	ST_LL
Cod	Pot	POT
Cod*	Jig	N/A
Aleutians		
Red King Crab*	Pot	N/A
Golden King Crab*	Pot	N/A
Atka Mackerel	Bottom Trawl	AM_TR
Cod	Bottom Trawl	PC_TR
Pollock	Bottom Trawl	PK_TR
Rockfish	Bottom Trawl	RR_TR
Sablefish/Turbot	Trawl	ST_TR
Pollock	Pelagic Trawl	PK_PTR
Cod	Longline	PC_LL
Sablefish/Turbot	Longline	ST_LL
Cod	Pot	POT
Gulf of Alaska		
Shallow Flatfish	Bottom Trawl	SF_TR
Rockfish	Bottom Trawl	RR_TR
Rockfish	Pelagic Trawl	RR_PTR
Pollock	Bottom Trawl	PK_TR
Pollock	Pelagic Trawl	PK_PTR
Cod	Bottom Trawl	PC_TR
Cod	Pot	PC_POT
Cod	Longline	PC_LL
Sablefish/Turbot	Longline	ST_LL
Deep Flatfish	Bottom Trawl	DF_TR
Cod*	Jig	N/A

* Not included in detailed analysis

Table B.2-4. Derivation of Fishing Effort Adjustments from Units Recorded by Observers to Square km

Gear	Vessel Class	Width (meters)	Speed (knots)	Observer Coverage	Distance (m)	Distance per Hook (m)	Proportion on Bottom	Unit	Area (km^2)/Unit
Bottom Trawl	Gt 125	166	3.6	1	N/A	N/A	1	hour	1.11
	Lt 125	90	3.3	0.32	N/A	N/A	1	hour	1.72
Rough Bottom	Gt 125	50	3.6	1	N/A	N/A	1	hour	0.33
Trawls (Aleutian)	Lt 125	50	3.3	0.32	N/A	N/A	1	hour	0.95
Pelagic Trawl	Gt 125	136	3.9	1	N/A	N/A	0.44	hour	0.43
	Lt 125	75	3.5	0.23	N/A	N/A	0.44	hour	0.93
Longline	Gt 125	2	N/A	1	N/A	1.28	1	hook	0.000003
	Lt 125	2	N/A	0.3	N/A	1.28	1	hook	0.000009
Pot	All	2.13	N/A	0.3	4.26	N/A	1	pot	0.000030

Table B.2-5. Estimates of the Q Parameter Used in the Analysis of Fishing Effects on Essential Fish Habitat

	Low Effect Estimate %	Central Estimate %	High Effect Estimate %	Quality Score	Comments
Bottom Trawls					
Infaunal Prey	5	11	21	6	several related studies
Soft Substrates					
Epifaunal Prey	4	10	17	6	several related studies
Living Structure	1	15	21	5	some related studies
Non-living Structure	0	2	5	4	value metric vague
Hard Substrates					
Epifaunal Prey	16	18.5	22	5	some related studies
Living Structure	10	20	30	5	some related studies
Non-living Structure	1	2	5	4	value metric vague
Hard Corals	22	27	35	4	few related studies
Pelagic Trawls (when contacting seafloor)					
Soft Substrates					
Infaunal Prey	4	21	36	4	two related studies
Epifaunal Prey	4	16.5	25.5	2	indirect rationale
Living Structure	10	20	30	2	indirect rationale
Non-living Structure	10	20	30	2	indirect rationale
Hard Substrates	0, not used on hard substrates (effort rescaled to reflect all efforts on soft portion)				
Longlines					
Infaunal Prey		0.05		3	rationale for low effect
Soft Substrates					
Epifaunal Prey		0.05		3	rationale for low effect
Living Structure		5		1	very indirect rationale
Non-living Structure		0.05		3	rationale for low effect
Hard Substrates					
Epifaunal Prey		0.05		3	rationale for low effect
Living Structure		10		1	very indirect rationale
Non-living Structure		0.05		2	indirect rationale
Hard Coral		0.05		1	very indirect rationale
Pots					
Infaunal Prey		26		2	indirect rationale
Epifaunal Prey		21.5		1	very indirect rationale
Living Structure		25		1	very indirect rationale
Non-living Structure		25		1	very indirect rationale
Hard Coral		35		1	very indirect rationale

Table B.2-6. Estimates of the Rho Parameter Used in the Analysis of Fishing Effects on Essential Fish Habitat

Substrate	Habitat Features	Low Effect Estimate %	Central Estimate %	High Effect Estimate %	Quality Score
Sand (soft substrate)	Infaunal Prey	8	4	3	4
	Epifaunal Prey	8	4	3	4
	Living Shelter	0.26	0.18	0.1	2
	Non-living Shelter	8	2	1	3
Mud - sand mix (soft substrate)	Infaunal Prey	2	1.33	1	4
	Epifaunal Prey	2	1.33	1	4
	Living Shelter	0.26	0.18	0.1	2
	Non-living Shelter	2	1	0.66	4
Mud - silt (soft substrate)	Infaunal Prey	2	1	0.66	4
	Epifaunal Prey	2	1	0.66	4
	Living Shelter	0.26	0.18	0.1	2
	Non-living Shelter	2	0.5	0.33	3
Pebble to rock (hard substrate)	Infaunal Prey	2	1	0.66	3
	Epifaunal Prey	2	1	0.66	3
	Living Shelter	0.09	0.05	0.01	3
	Non-living Shelter	0.02	0.01	0.005	3
	Hard Coral	0.02	0.01	0.005	3

Table B.2-7. Areas of Habitat Types Used in the Analysis of Fishing Effects on Essential Fish Habitat

Habitat Type	Area (Square km)	Split Percent	Quality Score
Bering Sea			
Sand	265,099	N/A	7
Sand/Mud	294,244	N/A	7
Mud	97,058	N/A	7
Norton Sound +	103,091	N/A	7
Slope	25,762	N/A	7
Bering Sea Total	785,254	N/A	
Aleutians			
Shallow			3
Sand	8,378	20%	1
Hard	33,510	80%	1
Shallow Total	41,117	100%	3
Deep			
Sand/Mud	13,760	20%	1
Hard	55,042	80%	1
Deep Total	68,802	100%	3
AleutianTotal	109,919	N/A	
Gulf of Alaska			
Shallow			
Sand	106,310	81%	1
Hard	24,937	19%	1
Shallow Total	131,247	100%	3
Shelf Deeps			
Sand/Mud	143,900	95%	1
Hard	7,574	5%	1
Shelf Deep Total	151,474	100%	3
Slope			
Sand/Mud	37,647	90%	1
Hard	4,183	10%	1
Slope Total	41,830	100%	3
Gulf of Alaska Total	324,550	N/A	
Grand Total	1,175,801	N/A	

Table B.2-8. Long-term Effect Indices (LEI* in % Reduction) for Fishing Effects on Benthic Habitat Features of Alaska Marine Waters by Habitat Type (Low and High LEIs in Parentheses)

	Soft Substrates (mud - gravel)									Hard Substrates (pebble - rock)				
Habitat	**Bering Sea**				**Aleutians**		**Gulf of Alaska**			**Aleutians**		**Gulf of Alaska**		
Features	**Sand**	**Sand/Mud**	**Mud**	**Slope**	**Shallow**	**Deep**	**Shallow**	**Deep Shelf**	**Slope**	**Shallow**	**Deep**	**Shallow**	**Deep Shelf**	**Slope**
Infauna Prey	0 (0-1)	2 (0-4)	0 (0-0)	3 (1-7)	0 (0-1)	1 (0-2)	0 (0-1)	1 (0-1)	1 (0-2)	0 (0-1)	0 (0-0)	1 (0-1)	0 (0-1)	0 (0-1)
Epifauna Prey	0 (0-1)	2 (0-3)	0 (0-0)	3 (0-6)	0 (0-1)	1 (0-2)	0 (0-0)	0 (0-1)	0 (0-1)	1 (0-1)	0 (0-0)	1 (0-1)	1 (0-1)	1 (0-1)
Living Structure	4 (1-6)	11 (3-19)	0 (0-1)	11 (4-19)	4 (1-7)	3 (1-4)	3 (1-5)	3 (1-6)	4 (0-7)	7 (3-17)	2 (1-7)	5 (2-10)	6 (3-13)	9 (4-21)
Non-living Structure	0 (0-1)	1 (0-3)	0 (0-0)	4 (1-7)	1 (0-1)	0 (0-0)	0 (0-1)	0 (0-1)	0 (0-1)	5 (5-11)	2 (1-4)	3 (1-7)	4 (2-9)	5 (2-14)
Hard Coral	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16 (11-20)	6 (4-9)	10 (8-12)	13 (10-16)	20 (14-25)

* LEI - Estimated eventual reduction in a class of habitat feature if recent fishing intensity and distribution were continued until fishing effect rates and habitat recovery rates equalized (equilibrium).

Table B.2-9. Long-term Effect Indicies (LEI*) Indicating the Effects of Fishing on Habitat Features by Fishery for the Features with the Highest LEIs in Each Region

Bering Sea (soft substrate)	**Sand/Mud Biostructure**	**Slope Biostructure**
Pollock Pelagic Trawl	4.6%	7.2%
Yellowfin Sole Trawl[1]	2.9%	0.2%
Flathead Sole/Flatfish Trawl[1]	1.8%	1.6%
Rock Sole Trawl[1]	0.9%	0.2%
Pollock Bottom Trawl[1]	0.4%	0.6%
Pacific Cod Trawl[1]	0.2%	0.4%
Sablefish/Turbot Trawl[1]	0.1%	0.7%
Pacific Cod Longline	0.0%	0.0%
Rockfish Trawl[1]	0.0%	0.0%
Pot	0.0%	0.0%
Sablefish/Turbot Longline	0.0%	0.0%
Total	**10.9%**	**10.9%**
[1] Total Bottom Trawl	6.3%	3.7%

Gulf of Alaska (hard substrate)	**Slope BioStructure**
Rockfish BottomTrawl	4.2%
Deep-water Flatfish Trawl	4.1%
Pacific Cod Trawl	0.2%
Shallow-water Flatfish Trawl	0.1%
Sablefish/Turbot Longline	0.1%
Pollock Bottom Trawl	0.0%
Pacific Cod Longline	0.0%
Pot	0.0%
Pollock Pelagic Trawl	0.0%
Rockfish Pelagic Trawl	0.0%
Total	**8.7%**

Aleutian Islands (hard substrate)	**Shallow BioStructure**
Pacific Cod Trawl	4.2%
Atka Mackeral Trawl	2.5%
Sablefish/Turbot Trawl	0.2%
Rockfish Trawl	0.2%
Pollock Bottom Trawl	0.1%
Pacific Cod Longline	0.1%
Sablefish/Turbot Longline	0.0%
Pot	0.0%
Pollock Pelagic Trawl	0.0%
Total	**7.3%**

* LEI - Estimated eventual reduction in a class of habitat feature if recent fishing intensity and distribution were continued until fishing effect rates and habitat recovery rates equalized (equilibrium).

Table B.3-1 Connections Between Life Stages of Managed Species and Habitat Features and Types Used in the Fishing Effects Analysis

		Soft Substrates									Hard Substrates					
Species &		Bering Sea				Aleutian Islands		Gulf of Alaska			Aleutian Islands		Gulf of Alaska			Any Substrate Any Region
Life Stage		Sand	Sand/Mud	Mud	Slope	Shallow	Deep	Shallow	Deepshelf	Slope	Shallow	Deep	Shallow	Deepshelf	Slope	Any Habitat
Red king crab									*					*		
egg	attached to female															
larvae	pelagic															
juvenile	benthic	**C, D**				**C**					**C**					**C,D**
adult	benthic	**A,B**	**A,B**			**A,B**					**A,B**					**A,B**
Blue king crab									*					*		
egg	attached to female															
larvae	pelagic															
juvenile	benthic	**C, D**	**C, D**													**C,D**
adult	benthic	**A,B**	**A,B**													**A,D**
Golden king crab									*					*		
egg	attached to female															
larvae	pelagic															
juvenile	benthic				**D**		**D**					**D**				**D**
adult	benthic				**A,B,C,D**		**A,B,C,D**					**A,B,C,D**				**A,B,C,D**
Scarlet king crab									*					*		
egg	attached to female															
larvae	pelagic															
juvenile	benthic				unknown		unknown					unknown				
adult	benthic				unknown		unknown					unknown				
Tanner crab									*					*		
egg	attached to female															
larvae	pelagic															
juvenile	benthic		**A,B**	**A,B**		**A,B**					**A,B**					**A,B**
adult	benthic		**A,B**	**A,B**		**A,B**					**A,B**					**A,B**
Snow crab									*					*		
egg	attached to female															
larvae	pelagic															
juvenile	benthic		**A,B**	**A,B**												**A,B**
adult	benthic		**A,B**	**A,B**												**A,B**
Deepwater Tanner crab									*					*		
egg	attached to female															
larvae	pelagic															
juvenile	benthic				unknown		unknown					unknown				
adult	benthic				unknown		unknown					unknown				
Walleye pollock																
egg	demersal															
larvae	pelagic															
juvenile	demersal/semi-pelagic															
adult	demersal/semi-pelagic															

Table B.3-1 Connections Between Life Stages of Managed Species and Habitat Features and Types Used in the Fishing Effects Analysis (cont.)

Species & Life Stage		Soft Substrates									Hard Substrates					Any Substrate
		Bering Sea				Aleutian Islands		Gulf of Alaska			Aleutian Islands		Gulf of Alaska			Any Region
		Sand	Sand/Mud	Mud	Slope	Shallow	Deep	Shallow	Deepshelf	Slope	Shallow	Deep	Shallow	Deepshelf	Slope	Any Habitat
Pacific cod																
egg	demersal															
larvae	pelagic															
juvenile	demersal	A,B	A,B	A,B		A,B	A,B	A,B	A,B		A,B		A,B	A,B		A,B
adult	demersal	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B	A,B
Sablefish																
egg	pelagic															
larvae	epipelagic															
juvenile	pelagic nearshore, then bent	A,B	A,B	A,B		A,B		A,B	A,B		A,B		A,B	A,B		A,B
adult	benthic slope				A,B		A,B			A,B		A,B			A,B	A,B
Atka mackerel																
egg	deposited in benthic nests										D		D[1]			D
larvae	pelagic															
juvenile	pelagic/benthic										D			D		D
adult	pelagic/benthic										D			D		D
1 / Atka mackerel nests with eggs have not been observed in the Gulf of Alaska, but the assumption is made that eggs would be found in the same substrate as observed in the Aleutian Islands.																
BSAI yellowfin sole									*					*		
egg	pelagic															
larvae	pelagic															
juvenile	benthic	B				B					B					B
adult	benthic	A,B	A,B			A,B					A,B					A,B
BSAI Greenland turbot									*					*		
egg	pelagic															
larvae	pelagic															
juvenile	benthic	B	B			B										B
adult	benthic	A,B	A,B		A,B	A,B	A,B				A,B	A,B				A,B
BSAI arrowtooth flounder									*					*		
egg	pelagic															
larvae	pelagic															
juvenile	benthic	B				B					B					B
adult	benthic	A,B	A,B		A,B	A,B	A,B				A,B	A,B				A,B
GOA arrowtooth flounder																
egg	pelagic															
larvae	pelagic															
juvenile	benthic							B					B			B
adult	benthic							A,B	A,B	A,B			A,B	A,B	A,B	A,B
BSAI rock sole									*					*		
egg	benthic															
larvae	pelagic															
juvenile	benthic	B				B					B					B
adult	benthic	A,B	A,B			A,B					A,B					A,B

Table B.3-1 Connections Between Life Stages of Managed Species and Habitat Features and Types Used in the Fishing Effects Analysis (cont.)

		Soft Substrates									Hard Substrates					
Species &		Bering Sea				Aleutian Islands		Gulf of Alaska			Aleutian Islands		Gulf of Alaska			Any Substrate Any Region
Life Stage		Sand	Sand/Mud	Mud	Slope	Shallow	Deep	Shallow	Deepshelf	Slope	Shallow	Deep	Shallow	Deepshelf	Slope	Any Habitat
Flathead sole																
egg	pelagic															
larvae	pelagic															
juvenile	benthic	**B**				**B**		**B**			**B**		**B**			**B**
adult	benthic	**A,B**	**A,B**			**A,B**		**A,B**	**A,B**		**A,B**		**A,B**	**A,B**		**A,B**
GOA rex sole																
egg	pelagic															
larvae	pelagic															
juvenile	benthic							**B**					**B**			**B**
adult	benthic							**A,B**	**A,B**				**A,B**	**A,B**		**A,B**
BSAI Alaska plaice									*					*		
egg	polagic															
larvae	pelagic															
juvenile	benthic	**B**				**B**					**B**					**B**
adult	benthic	**A,B**	**A,B**			**A,B**					**A,B**					**A,B**
GOA shallow water flatfish																
egg	benthic/pelagic															
larvae	pelagic															
juvenile	benthic							**B**					**B**			**B**
adult	benthic							**A,B**					**A,B**			**A,B**
GOA deep water flatfish																
egg	pelagic															
larvae	pelagic															
juvenile	benthic								**B**	**B**				**B**	**B**	**B**
adult	benthic								**A,B**	**A,B**				**A,B**	**A,B**	**A,B**
Pacific Ocean Perch																
egg	NA															
larvae	pelagic															
juvenile	demersal				**C,D**	**C,D**	**C,D**				**C,D**	**C,D**	**C,D**	**C,D**	**C,D**	**C,D**
adult	demersal				**D**	**D**	**D**		**C,D**	**C,D**	**D**	**D**		**C,D**	**C,D**	**C,D**
Rougheye/Shortraker																
egg	NA															
larvae	pelagic															
juvenile	demersal				**A,C,D**	**A,C,D**	**A,C,D**				**A,C,D**	**A,C,D**				**A,C,D**
adult	demersal				**A,C,D**		**A,C,D**					**A,C,D**			**D, E**	**A,C,D,E**
Northern Rockfish																
egg	NA															
larvae	pelagic															
juvenile	demersal				**C,D**	**C,D**		**C,D**	**C,D**		**C,D**		**C,D**	**C,D**		**C,D**
adult	demersal				**D**	**D**		**C,D**	**C,D**		**D**		**C,D**	**C,D**		**C,D**

Table B.3-1 Connections Between Life Stages of Managed Species and Habitat Features and Types Used in the Fishing Effects Analysis (cont.)

		Soft Substrates									Hard Substrates					
Species &		Bering Sea				Aleutian Islands		Gulf of Alaska			Aleutian Islands		Gulf of Alaska			Any Substrate Any Region
Life Stage		Sand	Sand/Mud	Mud	Slope	Shallow	Deep	Shallow	Deepshelf	Slope	Shallow	Deep	Shallow	Deepshelf	Slope	Any Habitat
GOA Light dusky rockfish			*			*					*					
egg	inside female															
larvae / postlarv	pelagic															
young juvenile	unknown															
older juvenile	demersal												C, D, E	C, D, E		C,D,E
adult	demersal													C, D		C,D
Combined Tally	**Habitat Feature**					**Number of species / life stages connected with each habitat feature**										
	Epifauna prey	12	16	7	7	12	8	6	7	4	13	7	7	7	4	23
	Infauna prey	19	17	7	5	17	6	11	8	5	17	5	10	8	5	30
	Living structure	2	$\boxed{1}$		$\boxed{4}$	4	5	1	1	1	$\boxed{4}$	4	4	$\boxed{6}$	$\boxed{2}$	11
	Non-living structure	2	1		6	5	5	1	1	1	$\boxed{8}$	6	5	$\boxed{9}$	$\boxed{3}$	16
	Hard corals												$\boxed{1}$	$\boxed{1}$	$\boxed{1}$	2

* - Not an FMP species in this region (they may be managed as part of an FMP species group)

$\boxed{}$ - Habitat types / features with long-term effect indices > 5%

All blank cells indicate that no connection was noted.

Key:

Habitat Feature:

A. **epifauna prey (e.g., diverse crustaceans, ophiuroids, snails)**
B. **infauna prey (e.g., clams, ploychaetes)**
C. **living structure (e.g., anemones, sponges, large ascidians, soft corals)**
D. **non-living structure (e.g., sand waves, rocks)**
E. **hard corals (e.g., Primnoa, some gorgonians)**

Habitat Type:

Bering Sea: Sand, mixed sand and mud, and mud substrates and the outer slope (200-1000 m)
Gulf of Alaska: Shallow (0-100 m), deeper shelf areas (100-300 m) and slope (200-1000 m) each separated into sand to gravel (soft) substrates and (hard) pebble to rock substrates
Aleutian Islands: Shallow (0-200 m) and deep (200-1000 m) both separated into soft and hard substrates.

Table B.3-2. Criteria for Assessing the Effects of Fishing on Essential Fish Habitat

	Intensity of Effect			
Issue	**MMNT**	**MT**	**B**	**U**
Spawning/Breeding: Potential for adverse effects on the reproductive success of stocks.	Effects of fishing expected to have an adverse effect on essential spawning, nursery, or settlement habitat which is more than minimal AND not temporary.	Fishing anticipated to have either minimal, temporary or no effects on essential spawning, nursery, or settlement habitat	Effects of fishing expected to have a positive effect on essential spawning, nursery, or settlement habitat which is more than minimal AND not temporary.	Magnitude and/or direction of effects are unknown.
Feeding: Potential for adverse effects on availability of significant prey resources for FMP species.	Effects of fishing on habitat expected to have an adverse effect on essential prey availability which is more than minimal AND not temporary.	Fishing anticipated to have either minimal, temporary or no effects on essential prey availability.	Effects of fishing on habitat expected to have a positive effect on essential prey availability which is more than minimal AND not temporary.	Magnitude and/or direction of effects are unknown.
Growth to Maturity: Potential for changing the survival rates of managed species as they are growing to maturity.	Effects of fishing on essential habitat expected to have an adverse effect on survival of fish to maturity which is more than minimal AND not temporary.	Fishing anticipated to have either minimal, temporary or no effects on the survival of fish to maturity	Effects of fishing on essential habitat expected to have a positive effect on survival of fish to maturity is expected which is more than minimal AND not temporary.	Magnitude and/or direction of effects are unknown.

MMNT = More than minimal and not temporary, MT = Minimal or Temporary, B = Beneficial, U = Unknown

The standard for MMNT or B ratings is that they are **neither minimal nor temporary**. These terms are described in more detail below. Effects based on the analysis of long-term effects on habitat features **(LEIs) are intrinsically not temporary**. Essential habitat is that necessary for the managed species to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. For purposes of this assessment, the ability to support a sustainable fishery is to be judged on the stock's ability to remain above the Minimum Stock Size Threshold (MSST). Unless you have knowledge of ecosystem functions requiring a higher stock level, the same measure shall be used to judge managed species' ability to contribute to a healthy ecosystem.

Additional information on minimal and temporary: The standard provided in the regulations for whether fisheries adversely affect EFH enough to require Council action is that such effects are more than minimal and not temporary. No numerical standards for minimal or temporary were provided. A commentary included with the final rule describes temporary impacts as those that are **limited in duration and that allow the particular environment to recover without measurable impact**. No time scale was attached to the term 'limited duration'. Therefore, the analysis of fishing effects was based on effects that would occur if current fishing levels were continued until affected habitat features reached an equilibrium level. Therefore, such effects would not be of limited duration and could persist (not recover) as long as the fishery continued at that level.

The same commentary describes minimal impacts as those that **may result in relatively small changes in the affected environment and insignificant changes in ecological functions**. In the EFH context, the terms 'environment' and 'function' refer to the features of the environment necessary for the spawning, breeding, feeding and growth to maturity of the managed species and the function of those features in providing that support. Therefore, a change in a habitat feature estimated in the effects-of-fishing analysis (LEI), that would significantly change its support of the species' spawning, breeding, feeding or growth to maturity would be considered more than minimal and not temporary.

Table B.3-3. Long-term Effect Indices (Percent Reduction) of Habitat Features within Intersections of Species Distributions and Habitat Types, Including Percent of Each Species Distribution within Each Habitat Type (Bold Outlines Around Habitat Types Containing 25% or More of Either General or Concentration Areas)

			Percent Reduction (General Distribution [95%]/Concentration [75%])									
	% of Area		Infauna Prey		Epifauna Prey		Living Structure		Non-living Structure		Hard Coral	
Habitat	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)
Red King Crab												
AI_Deep	0	0	0	0	1	0	7	2	4	1	16	8
AI_Shallow	2	1	0	0	0	0	6	3	3	1	17	10
BS_Sand	68	74	1	1	1	1	8	9	1	1	0	0
BS_Sand/Mud	30	25	7	7	6	6	35	35	5	5	0	0
BS_Slope	0	0	42	0	34	0	82	0	51	0	0	0
Total	100	100	3	3	2	2	16	16	2	2	0	0
Blue King Crab												
BS_Mud	27	20	0	0	0	0	0	0	0	0	0	0
BS_Sand	17	32	0	0	0	0	1	0	0	0	0	0
BS_Sand/Mud	57	48	1	0	0	0	4	1	1	0	0	0
Total	100	100	0	0	0	0	2	0	0	0	0	0
Golden King Crab												
AI_Deep	56	45	0	0	0	1	3	5	2	3	9	14
AI_Shallow	24	24	1	1	1	2	8	11	5	7	20	25
BS_Sand	3	11	4	3	3	3	17	17	6	6	0	0
BS_Sand/Mud	1	2	1	1	1	1	8	7	1	1	0	0
BS_Slope	10	18	3	4	3	3	14	15	4	4	0	0
GOA_Deep_Shelf	2	0	0	0	0	0	3	0	1	0	18	0
GOA_Slope	4	0	1	0	1	0	5	0	2	0	21	0
GOA_Shallow	0	0	0	0	0	0	0	0	0	0	0	0
Total	100	100	1	1	1	1	6	10	3	4	11	13
Tanner Crab												
AI_Deep	0	0	3	0	4	0	35	0	22	0	60	0
AI_Shallow	0	0	1	0	1	0	11	0	7	0	25	0
BS_Mud	1	0	1	0	1	0	7	0	3	0	0	0
BS_Sand	26	32	2	2	2	1	11	11	1	1	0	0
BS_Sand/Mud	71	68	3	4	2	3	15	20	2	3	0	0
BS_Slope	2	0	4	17	4	14	16	44	5	24	0	0
Total	100	100	3	3	2	3	14	17	2	3	0	0
Snow Crab												
BS_Mud	28	36	0	0	0	0	0	0	0	0	0	0
BS_Sand	7	7	2	0	2	0	9	4	1	0	0	0
BS_Sand/Mud	65	57	2	1	2	1	10	7	1	1	0	0
BS_Slope	0	0	0	0	0	0	2	0	1	0	0	0
Total	100	100	1	1	1	1	7	5	1	0	0	0

Table B.3-3. Long-term Effect Indices (Percent Reduction) of Habitat Features within Intersections of Species Distributions and Habitat Types, Including Percent of Each Species Distribution within Each Habitat Type (Bold Outlines Around Habitat Types Containing 25% or More of Either General or Concentration Areas) (cont.)

			Percent Reduction (General Distribution [95%]/Concentration [75%])									
	% of Area		Infauna Prey		Epifauna Prey		Living Structure		Non-living Structure		Hard Coral	
Habitat	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)
Walleye Pollock												
AI_Deep	6	6	0	0	0	0	3	3	2	2	7	8
AI_Shallow	4	5	1	1	1	1	7	7	4	4	16	16
BS_Mud	10	8	0	0	0	0	0	0	0	0	0	0
BS_Sand	21	22	1	1	1	1	6	6	1	1	0	0
BS_Sand/Mud	28	28	2	2	2	2	12	13	2	2	0	0
BS_Slope	3	3	2	2	2	2	9	9	2	2	0	0
GOA_Deep_Shelf	13	13	1	1	1	1	5	5	1	1	16	16
GOA_Slope	4	4	1	1	1	1	5	5	1	1	23	23
GOA_Shallow	11	12	0	0	0	0	4	4	1	1	12	12
Total	100	100	1	1	1	1	7	7	1	1	5	6
Pacific Cod												
AI_Deep	4	2	1	1	1	1	5	8	3	5	11	19
AI_Shallow	4	4	1	1	1	1	8	10	5	6	19	24
BS_Mud	7	6	0	0	0	0	1	1	0	0	0	0
BS_Sand	21	23	1	1	1	1	6	7	1	1	0	0
BS_Sand/Mud	32	36	2	2	2	2	11	13	2	2	0	0
BS_Slope	2	3	2	2	2	2	10	10	3	3	0	0
GOA_Deep_Shelf	15	14	1	1	1	1	4	6	1	1	15	19
GOA_Slope	2	1	1	2	1	1	7	9	2	2	31	43
GOA_Shallow	13	12	0	0	0	0	4	5	1	1	11	15
Total	100	100	1	1	1	1	7	8	1	2	6	6
Sablefish												
AI_Deep	17	10	0	0	1	1	4	5	2	3	8	12
AI_Shallow	3	2	2	2	2	4	15	26	9	16	32	54
BS_Sand	3	0	17	0	15	0	56	0	14	0	0	0
BS_Sand/Mud	11	1	5	20	4	18	21	66	4	7	0	0
BS_Slope	9	1	2	0	2	0	9	1	3	0	0	0
GOA_Deep_Shelf	35	47	1	1	1	1	6	8	1	1	21	31
GOA_Slope	16	32	1	1	1	1	4	5	1	1	21	24
GOA_Shallow	6	7	1	1	1	2	10	11	2	3	27	31
Total	100	100	2	1	2	1	9	8	2	2	14	27
Atka Mackerel												
AI_Deep	33	37	2	3	2	3	15	20	10	13	32	40
AI_Shallow	44	50	1	2	2	3	14	20	8	13	30	40
BS_Sand	1	2	37	38	31	32	81	84	37	38	0	0
GOA_Deep_Shelf	8	5	0	0	0	0	3	3	0	1	20	20
GOA_Slope	2	2	1	1	1	1	7	7	1	1	38	37
GOA_Shallow	11	4	0	0	0	0	3	1	1	0	17	8
Total	100	100	2	3	2	4	13	20	8	12	28	37

Table B.3-3. Long-term Effect Indices (Percent Reduction) of Habitat Features within Intersections of Species Distributions and Habitat Types, Including Percent of Each Species Distribution within Each Habitat Type (Bold Outlines Around Habitat Types Containing 25% or More of Either General or Concentration Areas) (cont.)

			Percent Reduction (General Distribution [95%]/Concentration [75%])									
	% of Area		Infauna Prey		Epifauna Prey		Living Structure		Non-living Structure		Hard Coral	
Habitat	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)
Yellowfin Sole												
AI_Deep	0	0	14	17	14	18	49	56	36	42	69	80
AI_Shallow	0	0	8	8	9	9	34	37	23	23	38	39
BS_Mud	1	0	0	0	0	0	0	0	0	0	0	0
BS_Sand	53	61	1	0	0	0	5	5	0	0	0	0
BS_Sand/Mud	43	39	2	3	2	3	13	18	1	2	0	0
BS_Slope	0	0	18	17	15	15	56	56	20	18	0	0
GOA_Deep_Shelf	0	0	6	0	5	0	39	0	9	0	0	0
Shallow	3	0	0	0	0	0	3	2	1	0	6	1
Total	100	100	1	2	1	1	8	10	1	1	0	0
Greenland Turbot												
AI_Deep	11	6	0	1	0	1	3	5	2	3	7	9
AI_Shallow	4	2	1	2	1	3	11	15	7	9	23	26
BS_Mud	18	14	0	0	0	0	0	1	0	0	0	0
BS_Sand	6	4	5	11	4	10	21	39	4	9	0	0
BS_Sand/Mud	56	65	2	3	2	2	12	14	2	2	0	0
BS_Slope	5	9	2	2	2	2	9	9	2	2	0	0
GOA_Deep_Shelf	0	0	2	0	2	0	11	0	3	0	51	0
GOA_Slope	0	0	4	0	3	0	18	0	6	0	53	0
GOA_Shallow	0	0	0	0	0	0	0	0	0	0	1	0
Total	100	100	2	2	2	2	9	12	2	3	2	1
Arrowtooth Flounder												
AI_Deep	6	2	1	2	1	2	5	11	3	7	11	21
AI_Shallow	4	1	1	2	1	3	10	23	6	14	22	42
BS_Mud	1	0	1	2	1	1	4	9	1	3	0	0
BS_Sand	7	4	3	10	3	8	20	39	3	8	0	0
BS_Sand/Mud	33	34	3	4	2	3	16	20	2	3	0	0
BS_Slope	3	5	2	3	2	2	10	12	3	3	0	0
GOA_Deep_Shelf	24	35	1	1	1	1	4	5	1	1	13	17
GOA_Slope	6	7	1	1	1	1	5	7	1	2	24	32
Shallow	16	11	0	1	0	1	4	9	1	2	13	26
Total	100	100	2	2	1	2	10	13	2	3	8	12

Table B.3-3. Long-term Effect Indices (Percent Reduction) of Habitat Features within Intersections of Species Distributions and Habitat Types, Including Percent of Each Species Distribution within Each Habitat Type (Bold Outlines Around Habitat Types Containing 25% or More of Either General or Concentration Areas) (cont.)

			Percent Reduction (General Distribution [95%]/Concentration [75%])									
	% of Area		Infauna Prey		Epifauna Prey		Living Structure		Non-living Structure		Hard Coral	
Habitat	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)
Rock Sole												
AI_Deep	3	1	1	3	1	3	7	16	4	11	16	32
AI_Shallow	6	3	1	1	1	1	7	10	4	6	17	22
BS_Mud	4	1	0	0	0	0	1	0	0	0	0	0
BS_Sand	28	37	1	1	1	1	6	6	1	1	0	0
BS_Sand/Mud	37	41	2	3	2	2	13	15	2	2	0	0
BS_Slope	2	1	3	2	2	1	11	9	3	2	0	0
GOA_Deep_Shelf	6	3	1	3	1	2	9	14	2	3	27	38
GOA_Slope	1	0	1	1	1	1	8	8	2	2	41	45
GOA_Shallow	13	13	0	1	0	1	5	6	1	2	14	17
Total	100	100	1	2	1	1	8	10	2	2	5	4
Flathead Sole												
AI_Deep	1	1	2	3	2	3	10	12	7	8	18	19
AI_Shallow	2	1	1	1	1	2	10	10	6	6	21	19
BS_Mud	12	7	0	0	0	0	0	1	0	0	0	0
BS_Sand	16	16	1	2	1	2	9	12	1	1	0	0
BS_Sand/Mud	35	41	2	3	2	2	13	15	2	2	0	0
BS_Slope	3	4	2	3	2	2	10	11	3	3	0	0
GOA_Deep_Shelf	15	15	1	1	1	1	5	6	1	1	17	19
GOA_Slope	2	1	1	2	1	2	9	10	2	3	39	40
GOA_Shallow	15	14	0	0	0	0	4	5	1	1	12	14
Total	100	100	1	2	1	2	8	10	1	2	5	6
Alaska Plaice												
AI_Deep	0	0	18	17	20	18	64	57	48	43	86	77
AI_Shallow	0	0	12	10	13	11	46	39	33	27	53	45
BS_Mud	5	5	0	0	0	0	0	0	0	0	0	0
BS_Sand	42	42	1	0	1	0	5	4	0	0	0	0
BS_Sand/Mud	52	52	2	2	2	2	12	10	1	1	0	0
BS_Slope	1	1	2	0	1	0	7	2	2	1	0	0
GOA_Deep_Shelf	0	0	2	0	1	0	10	0	2	0	14	0
GOA_Shallow	1	1	1	0	0	0	6	0	1	0	15	0
Total	100	100	1	1	1	1	9	7	1	1	0	0
Rex sole												
AI_Deep	3	2	1	4	1	4	8	18	5	13	16	33
AI_Shallow	2	2	2	4	2	4	16	25	10	16	32	44
BS_Sand	7	6	6	18	5	16	31	61	5	15	0	0
BS_Sand/Mud	29	9	4	9	3	7	21	37	4	9	0	0
BS_Slope	5	5	3	6	2	5	12	22	3	6	0	0
GOA_Deep_Shelf	34	51	1	1	1	1	5	8	1	1	17	31
GOA_Slope	9	14	1	1	1	1	6	9	1	2	28	39
GOA_Shallow	11	10	1	1	1	1	8	12	2	3	24	34
Total	100	100	2	3	2	3	12	16	3	4	12	26

Table B.3-3. Long-term Effect Indices (Percent Reduction) of Habitat Features within Intersections of Species Distributions and Habitat Types, Including Percent of Each Species Distribution within Each Habitat Type (Bold Outlines Around Habitat Types Containing 25% or More of Either General or Concentration Areas) (cont.)

			Percent Reduction (General Distribution [95%]/Concentration [75%])									
	% of Area		Infauna Prey		Epifauna Prey		Living Structure		Non-living Structure		Hard Coral	
Habitat	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)
Dover Sole												
AI_Deep	3	0	1	7	1	7	7	24	5	18	13	32
AI_Shallow	1	0	1	5	2	6	13	36	7	23	25	54
BS_Sand	2	1	17	10	14	9	70	72	14	6	0	0
BS_Sand/Mud	1	0	11	13	9	11	49	55	10	13	0	0
BS_Slope	0	0	17	0	14	0	47	0	19	0	0	0
GOA_Deep_Shelf	57	58	1	1	1	1	5	5	1	1	16	18
GOA_Slope	17	19	1	1	1	1	5	5	1	1	22	22
GOA_Shallow	20	21	1	1	1	1	7	8	2	2	21	24
Total	100	100	1	1	1	1	7	7	2	1	17	20
Pacific Ocean perch												
AI_Deep	21	26	1	1	1	1	5	9	3	5	12	21
AI_Shallow	10	13	1	1	2	2	13	17	8	10	28	38
BS_Sand	2	2	12	3	10	3	32	15	15	6	0	0
BS_Sand/Mud	5	4	2	1	1	1	9	6	2	1	0	0
BS_Slope	6	7	3	2	2	1	12	7	4	2	0	0
GOA_Deep_Shelf	32	30	1	1	1	1	7	10	1	1	29	46
GOA_Slope	16	16	1	1	1	1	6	9	1	2	27	43
GOA_Shallow	8	2	1	0	1	0	5	3	1	1	20	17
Total	100	100	1	1	1	1	8	10	3	4	20	31
Shortraker & Rougheye Rockfish												
AI_Deep	22	36	0	0	0	1	3	5	2	3	8	13
AI_Shallow	16	12	1	1	1	2	7	12	4	7	17	27
BS_Sand	1	0	20	5	17	4	40	16	24	8	0	0
BS_Sand/Mud	1	0	1	1	1	1	6	5	1	1	0	0
BS_Slope	5	2	3	3	2	3	11	13	3	4	0	0
GOA_Deep_Shelf	33	14	1	1	1	1	5	7	1	1	17	37
GOA_Slope	16	34	1	1	1	1	5	6	1	2	21	30
GOA_Shallow	6	1	1	0	1	0	6	5	1	1	16	28
Total	100	100	1	1	1	1	6	7	2	3	15	24
Northern Rockfish												
AI_Deep	19	17	1	1	1	2	6	13	4	8	16	28
AI_Shallow	27	21	1	1	1	2	8	16	5	10	19	34
BS_Sand	3	1	5	1	4	1	24	20	6	2	0	0
BS_Sand/Mud	3	1	3	0	3	0	15	3	4	0	0	0
BS_Slope	2	0	3	2	2	2	12	10	4	3	0	0
GOA_Deep_Shelf	26	37	2	1	1	1	10	10	1	1	41	42
GOA_Slope	8	10	2	2	1	1	10	9	2	2	43	43
GOA_Shallow	13	13	0	0	1	0	6	5	1	1	24	22
Total	100	100	1	1	1	1	9	11	3	4	25	35

Table B.3-3. Long-term Effect Indices (Percent Reduction) of Habitat Features within Intersections of Species Distributions and Habitat Types, Including Percent of Each Species Distribution within Each Habitat Type (Bold Outlines Around Habitat Types Containing 25% or More of Either General or Concentration Areas) (cont.)

			Percent Reduction (General Distribution [95%]/Concentration [75%])									
	% of Area		Infauna Prey		Epifauna Prey		Living Structure		Non-living Structure		Hard Coral	
Habitat	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)	(95%)	(75%)
Dusky Rockfish												
AI_Deep	3	1	4	4	6	6	26	39	18	26	45	63
AI_Shallow	3	1	4	3	6	4	35	31	23	20	61	55
BS_Sand	3	0	22	0	19	0	66	0	15	0	0	0
BS_Sand/Mud	1	0	6	0	5	0	23	0	7	0	0	0
BS_Slope	0	0	2	0	2	0	12	0	3	0	0	0
GOA_Deep_Shelf	57	69	1	1	1	1	8	10	1	1	31	46
GOA_Slope	14	19	1	1	1	1	8	10	2	2	38	45
GOA_Shallow	20	11	1	1	1	1	7	8	2	2	25	38
Total	100	100	2	1	2	1	11	10	3	2	31	45
Yelloweye Rockfish												
AI_Deep	6	2	1	2	1	2	8	19	5	12	20	36
AI_Shallow	2	1	1	2	2	3	15	26	9	16	34	46
BS_Sand	0	0	10	0	9	0	42	0	8	0	0	0
BS_Sand/Mud	0	0	17	0	14	0	54	0	22	0	0	0
BS_Slope	0	0	7	0	6	0	30	0	8	0	0	0
GOA_Deep_Shelf	57	60	1	1	1	1	6	7	1	1	30	35
GOA_Slope	25	32	1	1	1	1	8	9	2	2	33	37
GOA_Shallow	11	6	0	0	0	0	6	5	2	1	28	24
Total	100	100	1	1	1	1	7	8	2	2	30	35
Thornyheads												
AI_Deep	27	23	0	0	0	1	3	4	2	2	7	9
AI_Shallow	7	5	1	1	1	2	11	12	6	7	24	27
BS_Sand	1	1	20	17	17	14	42	38	22	20	0	0
BS_Sand/Mud	2	1	1	1	1	1	7	7	1	1	0	0
BS_Slope	10	12	2	2	2	1	8	8	2	2	0	0
GOA_Deep_Shelf	30	33	1	1	1	1	5	4	1	1	20	18
GOA_Slope	19	22	1	1	1	1	4	5	1	1	21	23
GOA_Shallow	4	2	0	0	0	0	4	2	1	1	15	14
Total	100	100	1	1	1	1	6	5	2	2	14	15

Table B.4-1. Ratings of the Effects of Fishing on Essential Fish Habitat by Species and Life-history Process

Life -History Process	Walleye Pollock	Pacific Cod	Sablefish	Atka Mackerel	Yellowfin Sole (BSAI)	Greenland Turbot (BSAI)	Arrowtooth Flounder	Rock Sole (BSAI)	Flathead Sole	Rex Sole (GOA)	Alaska Plaice (BSAI)	Shallow Water Flatfish (GOA)	Deep Water Flatfish (GOA)	Pacific Ocean Perch (BSAI)	Pacific Ocean Perch (GOA)	Shortraker/Rougheye Rockfish (BSAI)	Shortraker/Rougheye Rockfish (GOA)	Northern Rockfish (BSAI)	Northern Rockfish (GOA)	Pelagic Shelf Rockfish (GOA)	Shortspine Thornyheads	Other Rockfish Species	Sharks	Skates	Sculpins	Squids	Octopi	Osmeridae	Myctophidae	Ammodytidae	Trichodontidae	Pholidae	Stichaeidae	Gonostomatidae	Euphausiacea
Spawning/Breeding	MT	MT	MT	MT	MT	MT	MT	MT	MT	U	MT	U	U	MT	MT	U	U	MT	MT	U	MT	U	U	U	U	U	U	MT	MT	MT	MT	MT	MT	MT	MT
Feeding	MT	MT	MT	MT	MT	MT	MT	MT	MT	U	MT	U	U	MT	MT	U	MT	MT	MT	MT	MT	U	U	U	U	U	U	MT	MT	MT	U	MT	MT	MT	MT
Growth to Maturity	MT	MT	MT	MT	MT	MT	MT	MT	MT	U	MT	U	U	MT	MT	U	U	MT	MT	U	MT	U	U	U	U	U	U	MT	MT	MT	U	MT	MT	MT	MT

Rating codes: MMNT - More than Minimal and Not TemporaryA - Adverse, MT - Minimal, Temporary or None, B - Beneficial, U - Unknown effect

Table B.4-2. Summary of the Effects of Status Quo Fishing Activities on EFH for Managed Species[1]

Area	Species	Overall Evaluation	Comments/Concerns
Alaska	Salmon	MT	Habitat types used by salmon species are not substantially afected by fishing.
Alaska	Weathervane Scallops	MT/U	This species does not depend upon any habitat feature vulnerable to groundfish fishing activities. Based on the overlap of fisheries with juvenile and adult scallop stock distribution, there appear to be minimal effects on the weathervane scallop habitat.
Alaska	Red King Crab	MT/U	Fishing activities are considered to have overall minimal and temporary effects on EFH for red king crab. Fishing activities thought to have adverse consequences to red king crab stocks have previously been mitigated by establishment of trawl closure areas.
Alaska	Blue King Crab	MT/U	Although both the Pribilof Islands stock and St. Matthew stock of blue king crabs are considered to be below MSST, habitat loss or degradation by fishing activities is not thought to have played any role in the decline of these stocks.
Alaska	Golden King Crab	MT/U	Fishing activities are considered to have overall minimal and temporary effects on the EFH of golden king crab. Groundfish trawl fishing in the Bering Sea slope is of some concern; however, any effects are thought to be minimal.
Alaska	Scarlet King	MT/U	This is a deepwater species with almost no overlap with commercial fisheries, so habitat effects are unlikely.
Alaska	Tanner Crab	MT	Fishing activities are considered to have overall minimal and temporary effects on EFH for Tanner crabs.
Alaska	Snow Crab	MT	Fishing effects on EFH are considered to have overall minimal and temporary effects on the EFH for snow crabs.
Alaska	Deepwater Tanner Crabs	MT/U	These are deepwater species with almost no overlap with commercial fisheries, so habitat effects are unlikely.
BSAI	Walleye Pollock	MT	Low association with benthic habitats. Pollock eggs, older juveniles, and adults are not primarily associated with benthic habitats.
BSAI GOA	Pacific Cod	MT	Nothing in the current fishery management regime jeopardizes the ability of the BSAI or GOA cod stocks to maintain themselves at or above their respective MSSTs.

Table B.4-2. Summary of the Effects of Status Quo Fishing Activities on EFH for Managed Species[1] (continued)

Area	Species	Overall Evaluation	Comments/Concerns
BSAI GOA	Sablefish	MT	The fishing effects of the current fishery management regime are either minimal or temporary, based on the criterion that sablefish currently are above MSST. However, caution is warranted, as little is known about sablefish spawning habitat and the effects of fishing on that habitat.
BSAI	Atka	MT	A 15 percent reduction in non-living substrate in the AI shallow waters may affect spawning habitat; however, empirical evidence (ability for the stock to remain above MSST) indicates minimal effects on breeding success and subsequent recruitment
BSAI	Yellowfin Sole	MT	The yellowfin sole stock is currently at a high level of abundance and well above the MSST. Nothing in the current fishery management regime jeopardizes the ability of the yellowfin sole stocks to maintain themselves at or above MSST.
BSAI	Greenland Turbot	MT	Nothing in the current fishery management regime jeopardizes the ability of the Greenland turbot stocks to maintain themselves at or above MSST.
BSAI GOA	Arrowtooth Flounder	MT	The arrowtooth flounder stock is currently at a high level of abundance due to sustained above-average recruitment in the 1980s and 1990s. The effects of fishing are not anticipated to have a substantial impact on spawning, adult feeding, or juvenile survival and growth to maturity.
BSAI	Rock Sole	MT	Nothing in the current fishery management regime jeopardizes the ability of the rock sole stocks to maintain themselves at or above MSST. The effects of fishing are not anticipated to have a substantial impact on spawning, adult feeding, or juvenile survival and growth to maturity.
BSAI	Flathead Sole	MT	The flathead sole stock is currently at a high level of abundance due to sustained above-average recruitment in the 1980s. The effects of the reductions in habitat features are either minimal or temporary in terms of the flathead sole stocks' abilities to maintain themselves at or above MSST.
GOA	Flathead Sole	MT	Stock assessment modeling indicates that flathead sole are at a stable level above the MSST threshold.
GOA	Rex Sole	U	Information is not available to estimate the stock size of the GOA rex sole population relative to its MSST.

Table B.4-2. Summary of the Effects of Status Quo Fishing Activities on EFH for Managed Species[1] (continued)

Area	Species	Overall Evaluation	Comments/Concerns
BSAI	Alaska Plaice	MT	The Alaska plaice stock is currently at a high level of abundance and is well above its MSST.
GOA	Shallow Water Flatfish	U	The level of information available for rock sole and the other species of the shallow water complex are insufficient to estimate the stock size relative to MSST, although trawl survey abundance estimates indicate a stable level of biomass since 1984.
GOA	Deep Water Flatfish	U	The level of information available for Dover sole and the other species of the deep water complex isinsufficient to estimate the stock size relative to MSST, although trawl survey abundance estimates indicate a stable level of biomass since 1984.
BSAI	Pacific Ocean Perch	MT	As determined in the draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the Pacific ocean perch stock to maintain themselves at or above their respective MSSTs.
GOA	Pacific Ocean Perch	MT	Though more is known about the life history of Pacific ocean perch than about other rockfish species, much uncertainty still exists about specific habitat preferences. However, nothing in the current fishery management regime jeopardizes the ability of the Pacific ocean perch stock to maintain themselves at or above their respective MSSTs.
BSAI	Shortraker and Rougheye Rockfish	U	Information is lacking regarding the habitat requirements for feeding, reproduction, and growth to maturity for both species in the Bering Sea and Aleutian Islands.
GOA	Shortraker and Rougheye Rockfish	MT/U	Fishing probably has little or no effect on prey availability to adult shortraker and rougheye rockfish in the Gulf of Alaska. However, habitat requirements for the various life stages and information on the reproductive behavior of both species are mostly unknown.
BSAI	Northern Rockfish	MT	A reduction in living and non-living structure may affect growth to maturity due to a reduction in refuge habitat for juveniles. Although the extent to which northern rockfish use rocky habitats as refuges is uncertain, the percent reductions of these habitat features are generally small and would be expected to have minimal and temporary effects.

Table B.4-2. Summary of the Effects of Status Quo Fishing Activities on EFH for Managed Species[1] (continued)

Area	Species	Overall Evaluation	Comments/Concerns
GOA	Northern Rockfish	MT	A reduction in living and non-living structure could plausibly jeopardize growth to maturity due to a reduction of refuge habitat for juvenile Gulf of Alaska northern rockfish. However, as determined in the draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the northern rockfish to maintain themselves at or above their respective MSSTs.
GOA	Pelagic Shelf Rockfish	MT/U	The effects of fishing on the habitat of light dusky rockfish are either unknown or negligible. However, there is some information to suggest that bottom trawling may have a negative impact on the benthic habitat, especially corals and sponges, that is used by juvenile and adult fish.
GOA	Thornyhead Rockfish	MT	Thornyhead juveniles and adults are associated with benthic habitats, specifically, on the deep shelf and slope in any type of non-living substrate, but they may prefer hard, non-living substrate according to limited studies in the eastern Gulf of Alaska.
BSAI	Other Rockfish	U	Studies conducted in the Bering Sea or Aleutian Islands are inconclusive as to whether fishing activities have an effect on the habitat (relative to spawning/breeding, feeding, and growth to maturity) of light dusky rockfish and BSAI thornyhead rockfish.
BSAI	Other Species	U	Because appropriate information is lacking for the "other species" (i.e.,sharks, skates, sculpins, squids, and octopi) it is impossible to assess whether the fisheries, as they are currently conducted off Alaska, are affecting habitat that is essential to the welfare of the species in question in a way that is more than minimal and not temporary.
Alaska	Forage Species	MT/U	Most of the forage species (i.e., Osmeridae, Myctophidae, Ammodytidae, Trichodontidae, Pholidae, Stichaeidae, Gonostomatidae, and Euphausiacea) do not overlap with known areas of intensive fishing, and/or there is little evidence that survival depends habitat affected by fishing.

[1] Based on information contained in Appendix B, Section 3.2. Evaluation notation is as follows: MT = minimal, temporary, or no effect; U = unknown; MMNT = more than minimal and not temporary.

Figure B.2-1 Habitats Used for Evaluation of Fishing Activities

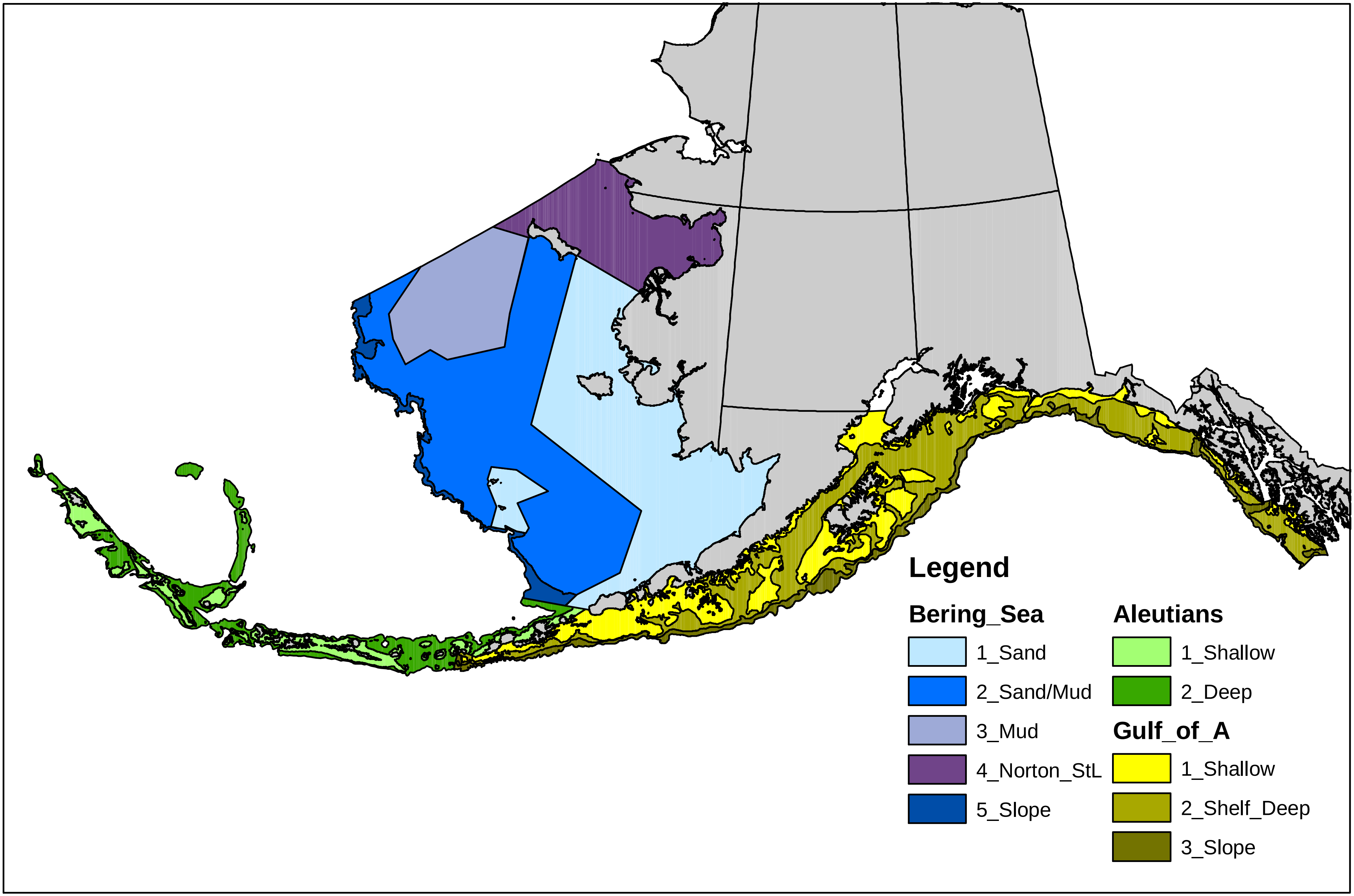
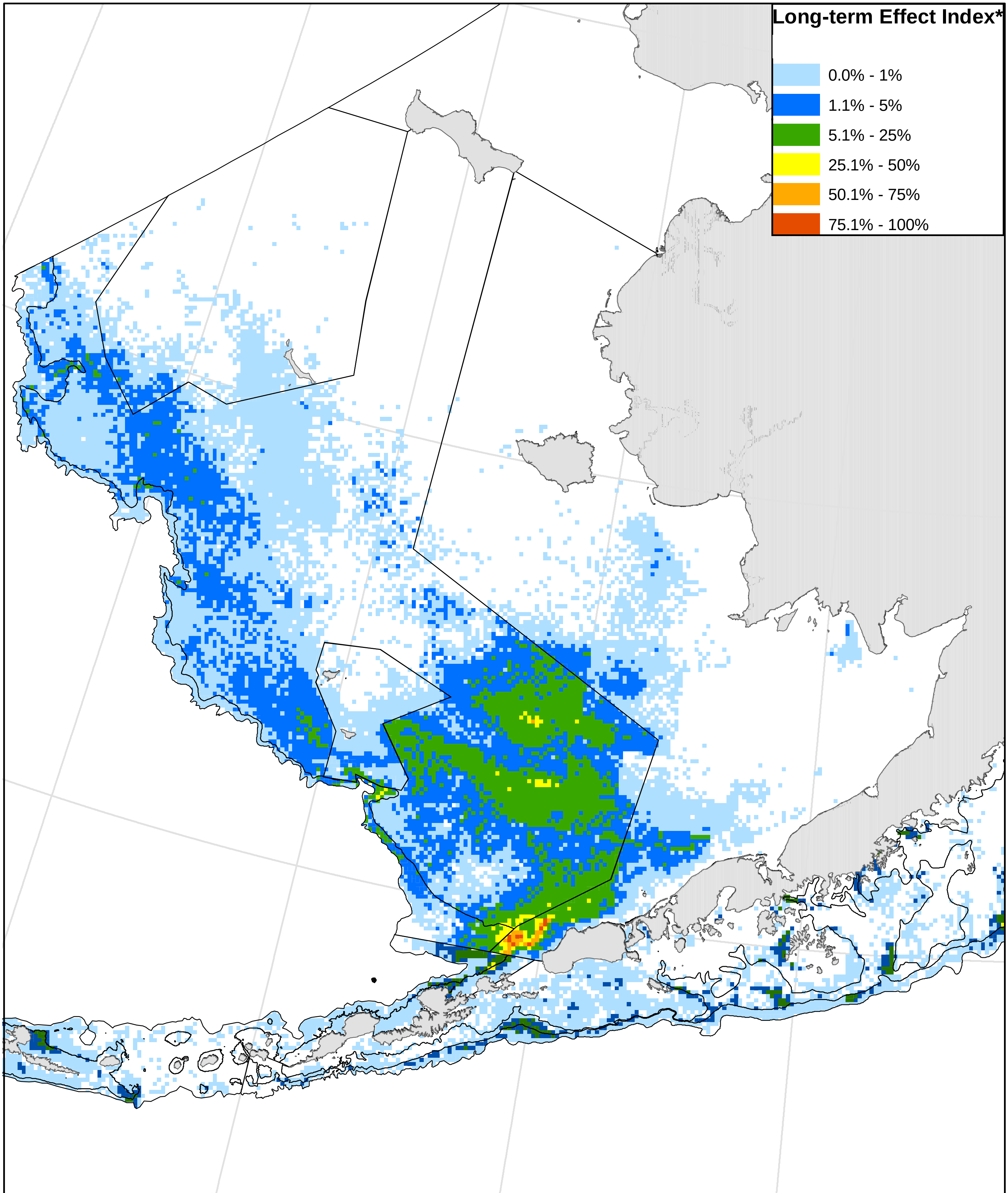


Fig B.2-2a. Distribution of Long-term Effect Index (LEI) of fishing effects on infauna prey- Bering Sea



* Long-term Effect Index - Estimated eventual reduction of the habitat feature if recent fishery intensity and distribution were continued until fishing effect rates and habitat recovery rates equalize (equilibrium)

Fig B.2-2b. Distribution of Long-term Effect Index (LEI) of fishing effects on infauna prey - Gulf of Alaska

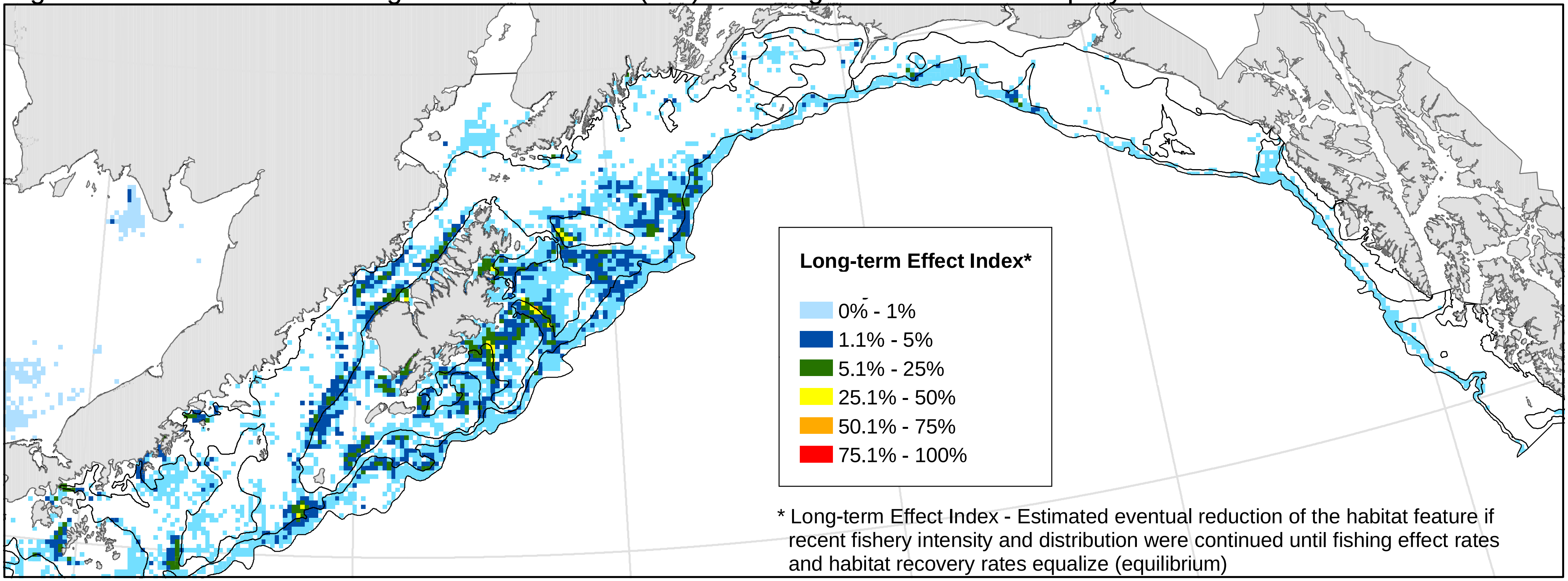


Fig B.2-2c. Distribution of Long-term Effect Index (LEI) of fishing effects on infauna prey - Aleutian Islands

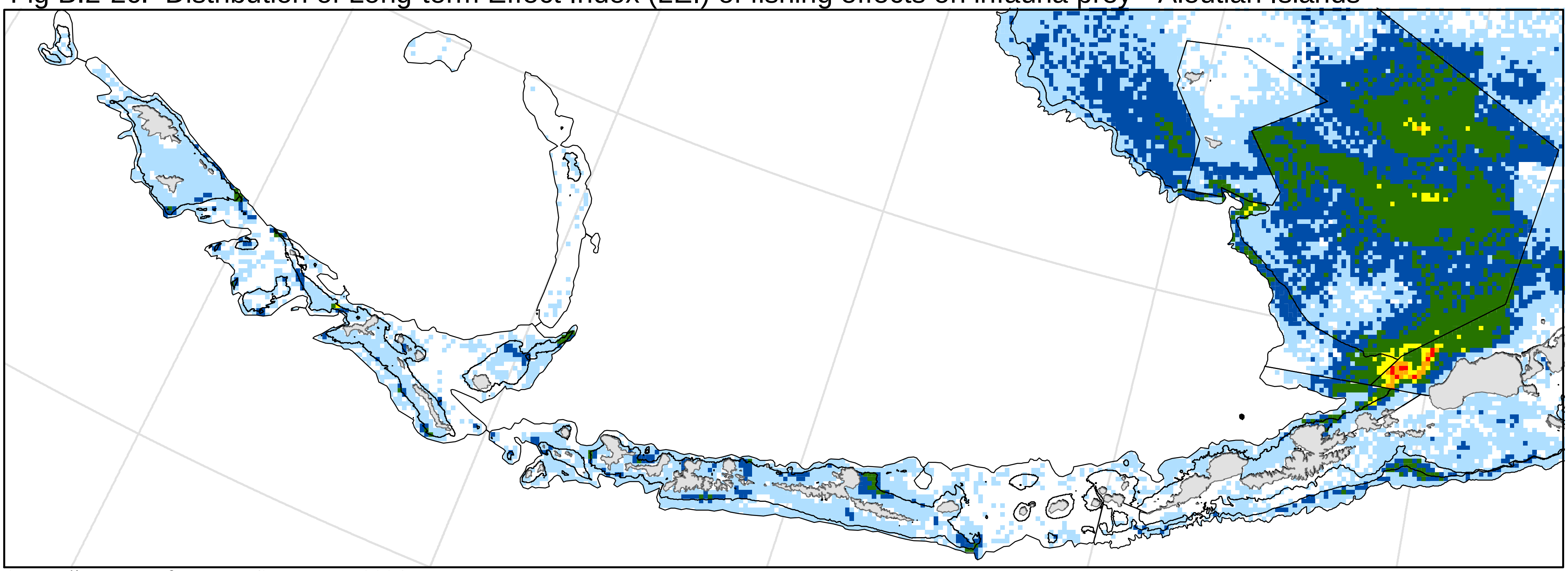
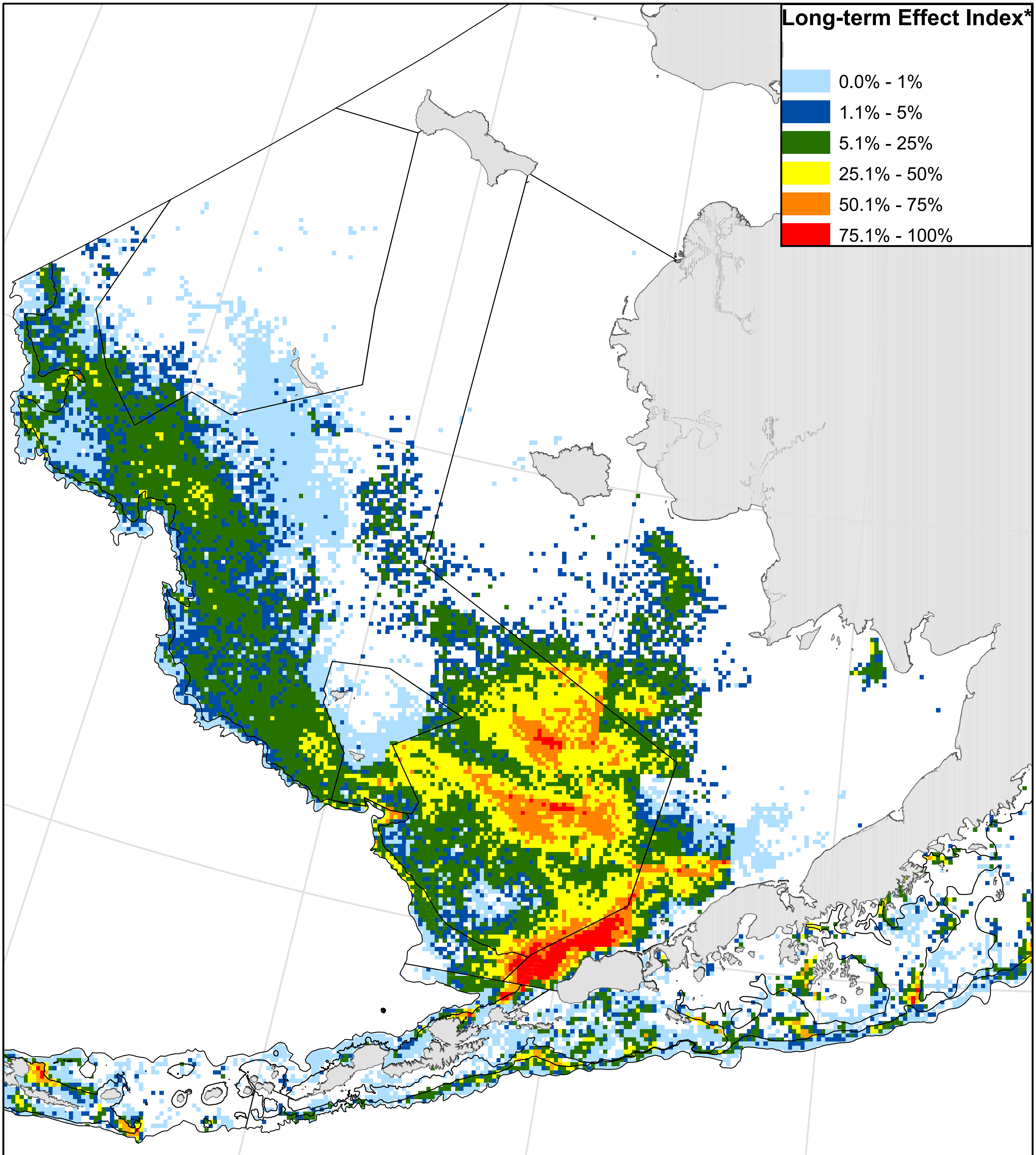


Fig B.2-3a. Distribution of Long-term Effect Index (LEI) of fishing effects on living structure - Bering Sea



* Long-term Effect Index - Estimated eventual reduction of the habitat feature if recent fishery intensity and distribution were continued until fishing effect rates and habitat recovery rates equalize (equilibrium)

Fig B.2-3b. Distribution of Long-term Effect Index (LEI) of fishing effects on living structure - Gulf of Alaska

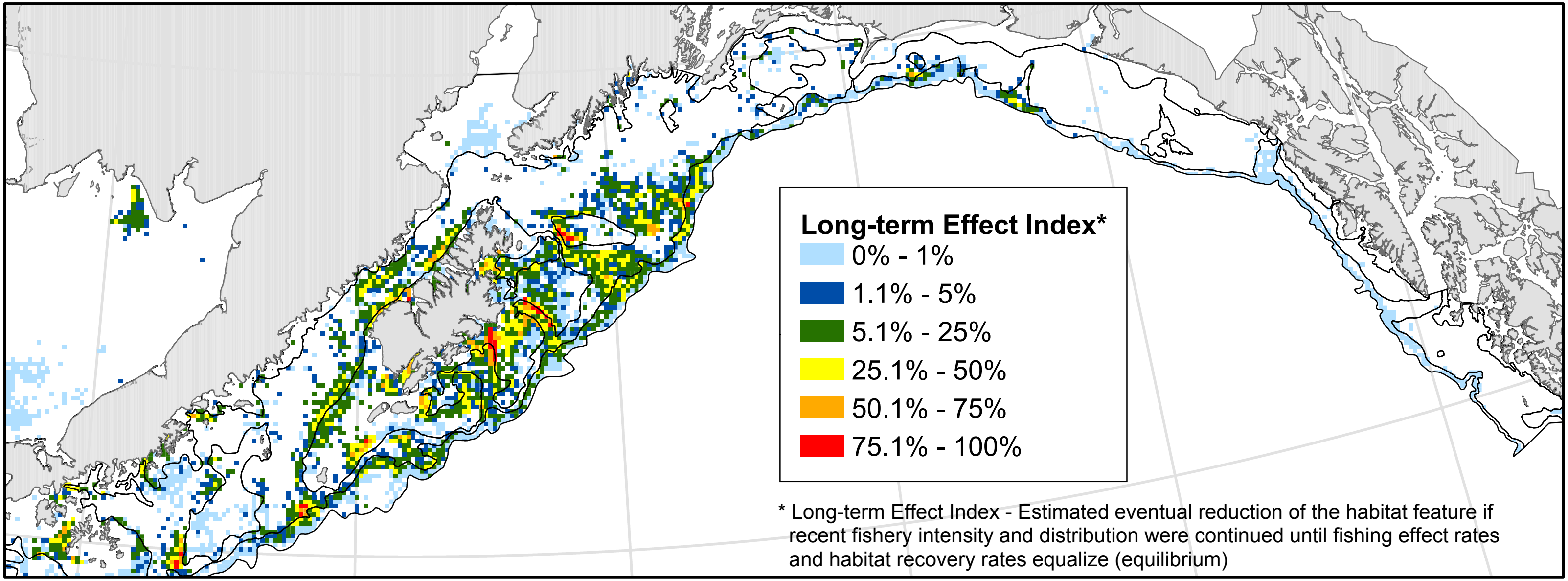


Fig B.2-3c. Distribution of Long-term Effect Index (LEI) of fishing effects on living structure - Aleutian Islands

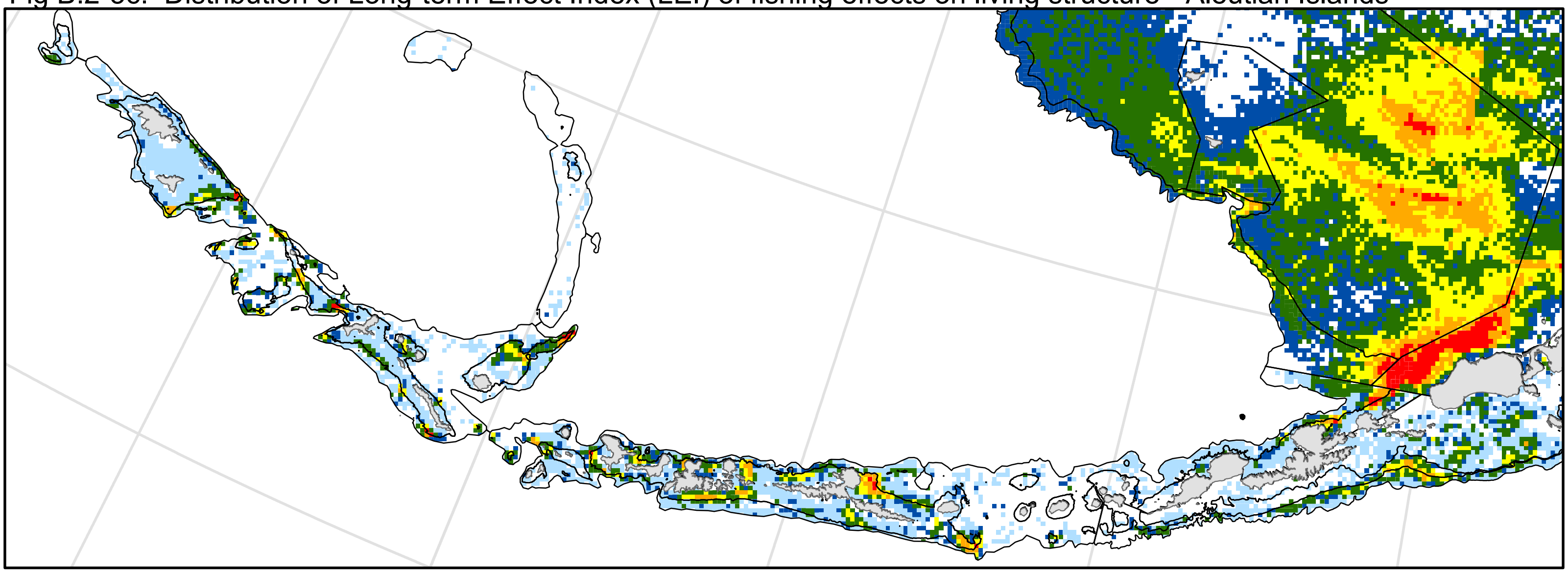
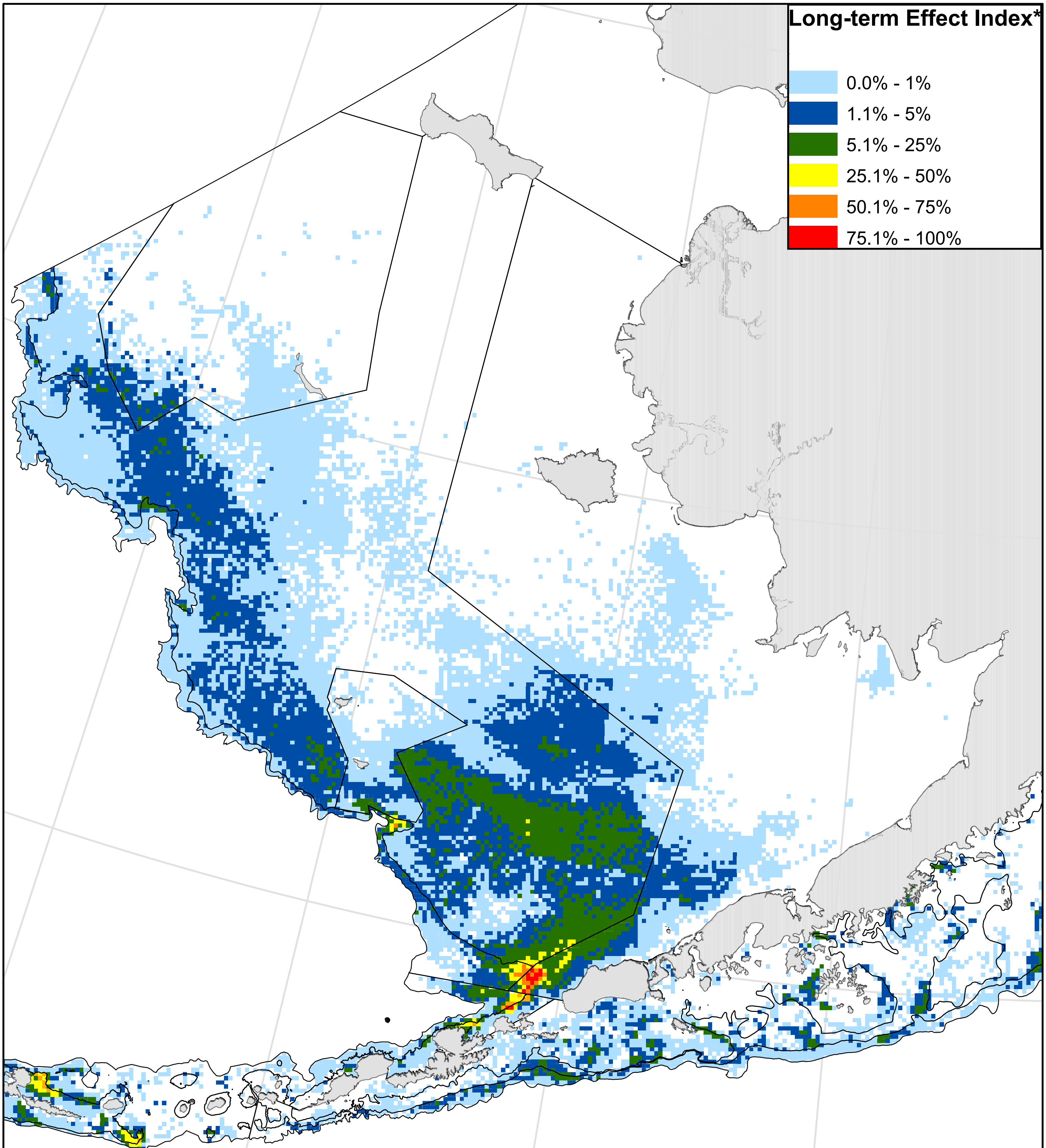


Fig B.2-4a. Distribution of Long-term Effect Index (LEI) of fishing effects on non-living structure - Bering Sea



* Long-term Effect Index - Estimated eventual reduction of the habitat feature if recent fishery intensity and distribution were continued until fishing effect rates and habitat recovery rates equalize (equilibrium)

Fig B.2-4b. Distribution of Long-term Effect Index (LEI) of fishing effects on non-living structure - Gulf of Alaska

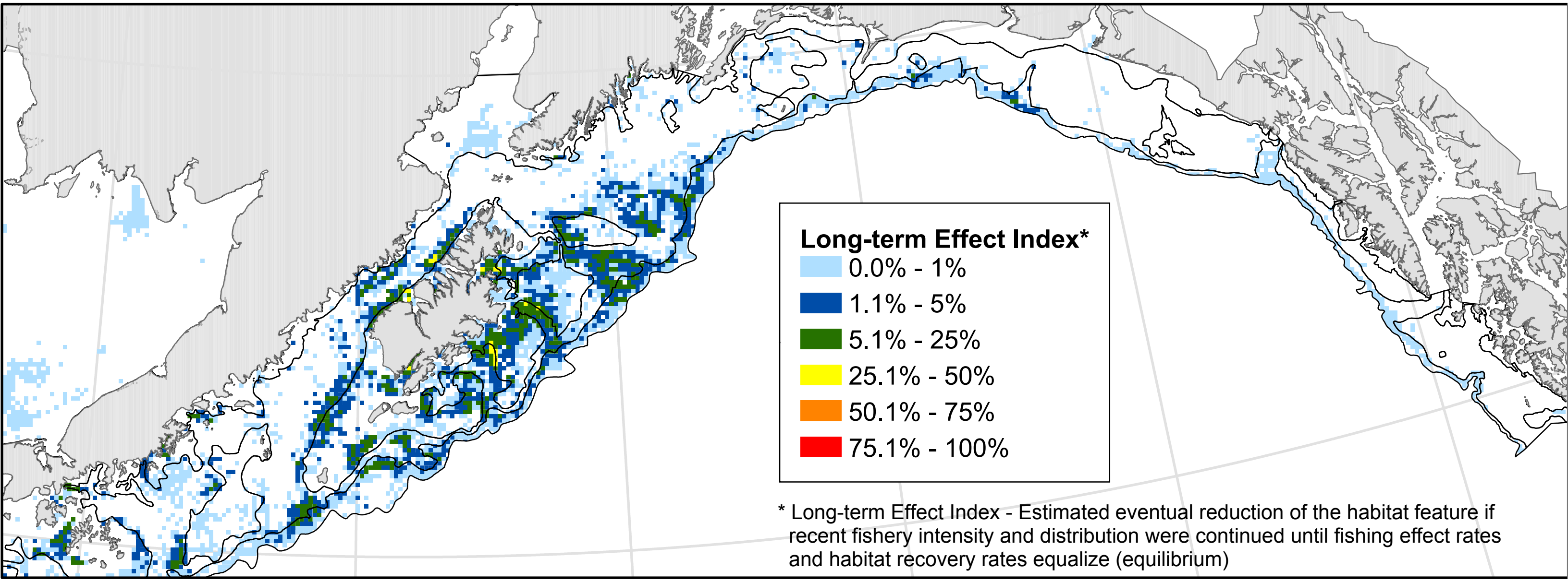


Fig B.2-4c. Distribution of Long-term Effect Index (LEI) of fishing effects on non-living structure - Aleutian Islands

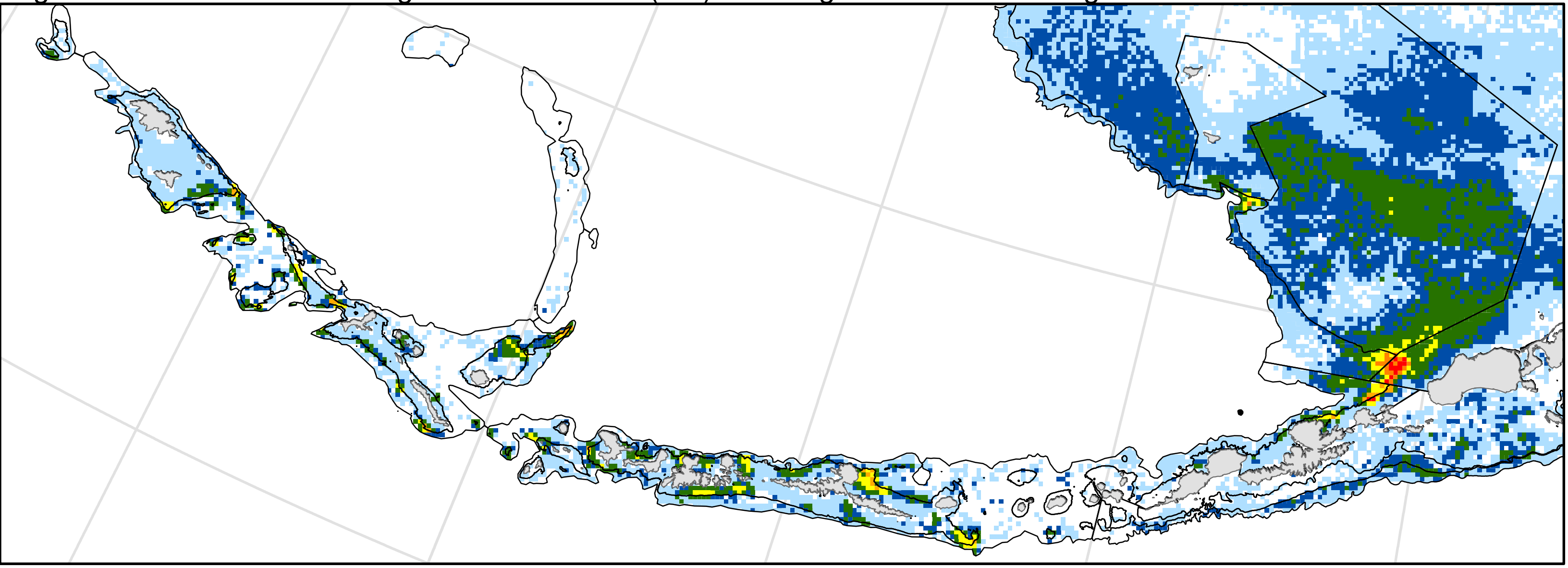
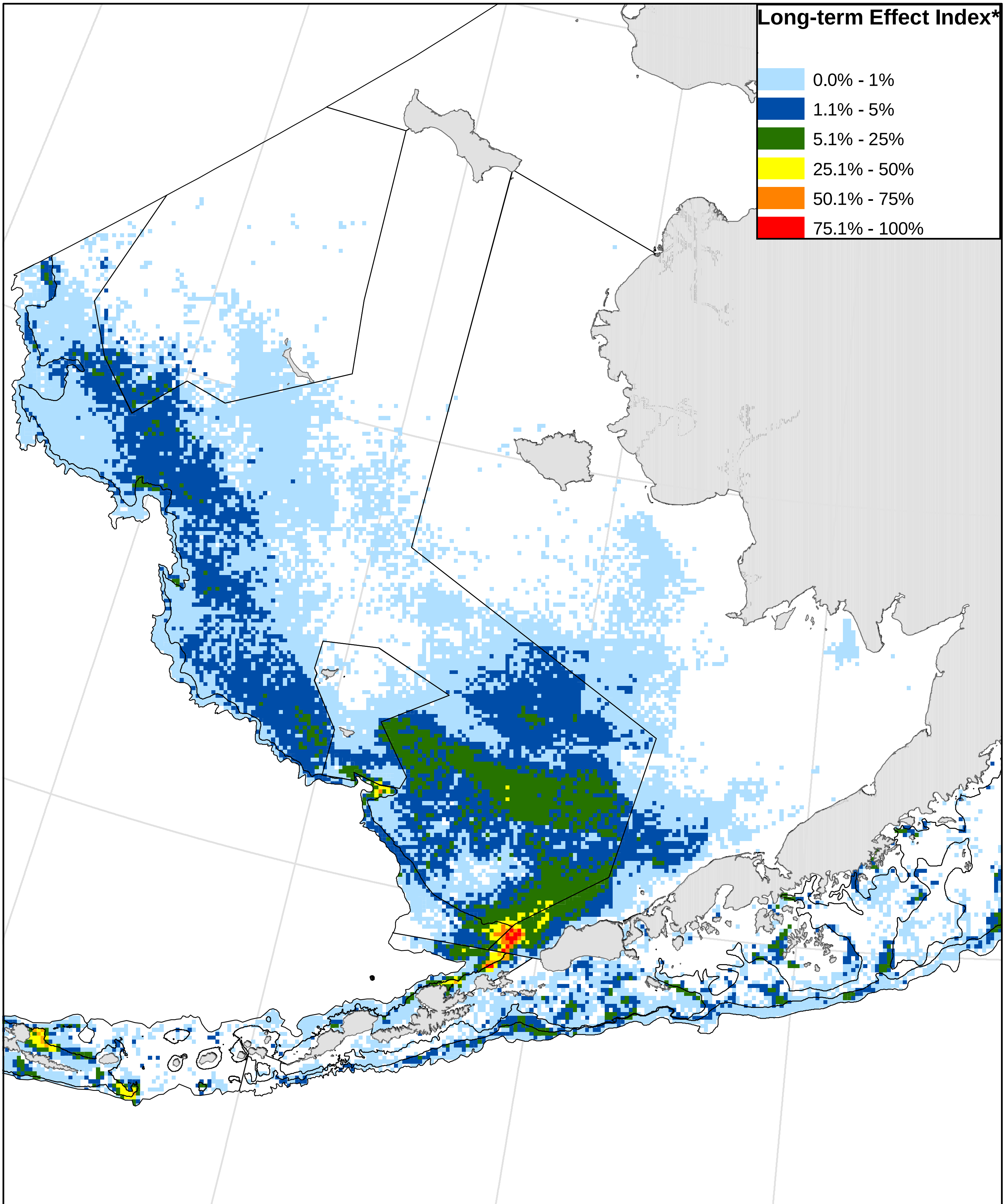


Fig B.2-5a. Distribution of Long-term Effect Index (LEI) of fishing effects on non-living shelter - Bering Sea



* Long-term Effect Index - Estimated eventual reduction of the habitat feature if recent fishery intensity and distribution were continued until fishing effect rates and habitat recovery rates equalize (equilibrium)

Fig B.2-5b. Distribution of Long-term Effect Index (LEI) of fishing effects on non-living shelter - Gulf of Alaska

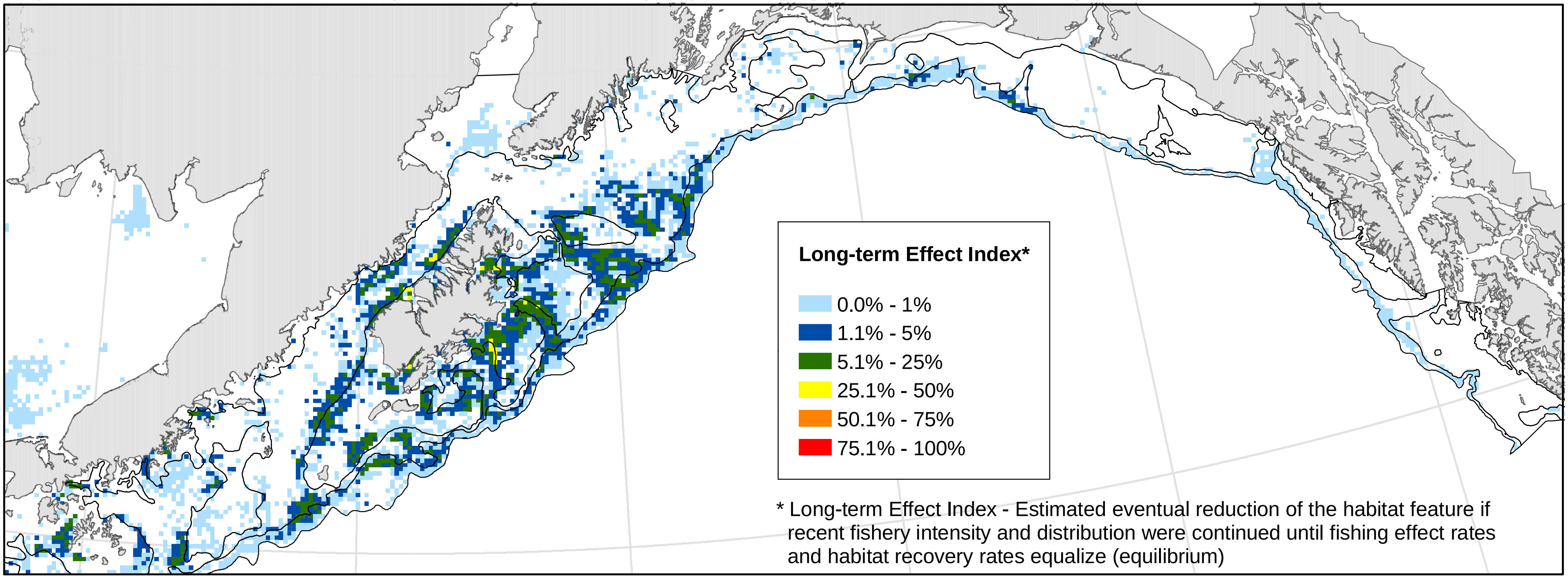


Fig B.2-5c. Distribution of Long-term Effect Index (LEI) of fishing effects on non-living shelter - Aleutian Islands

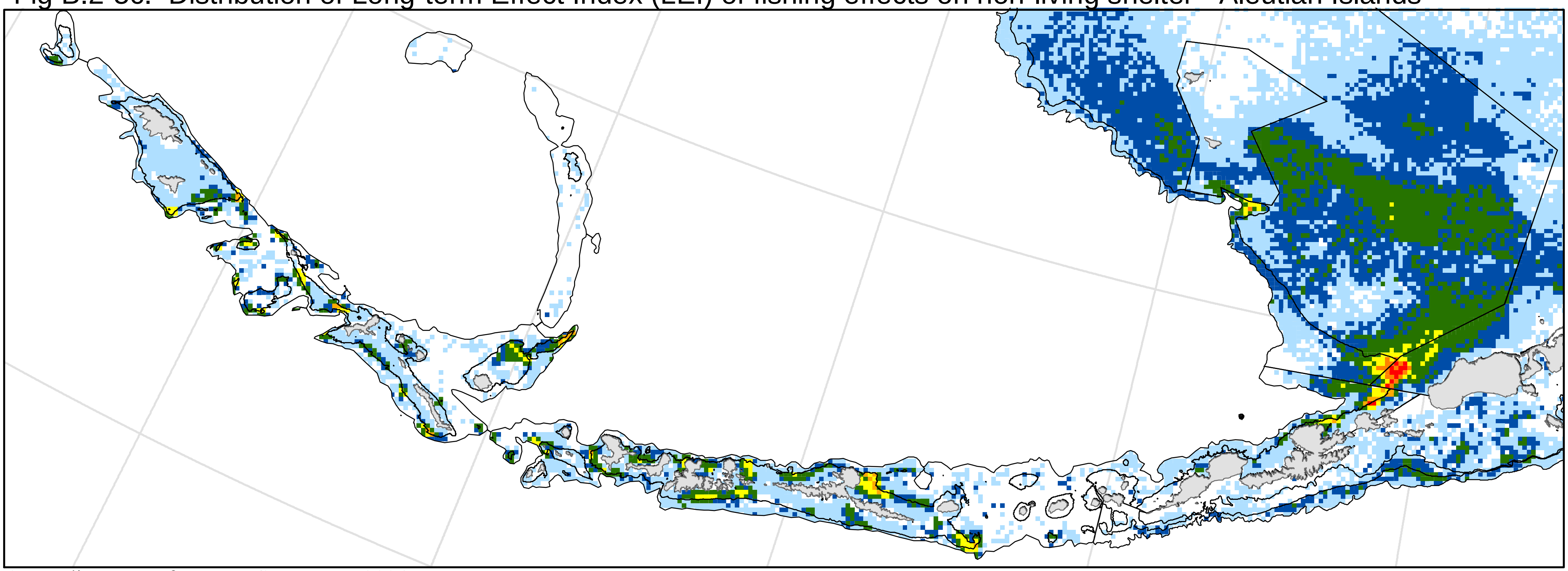


Fig B.2-6a. Distribution of Long-term Effect Index (LEI) of fishing effects on coral - Bering Sea

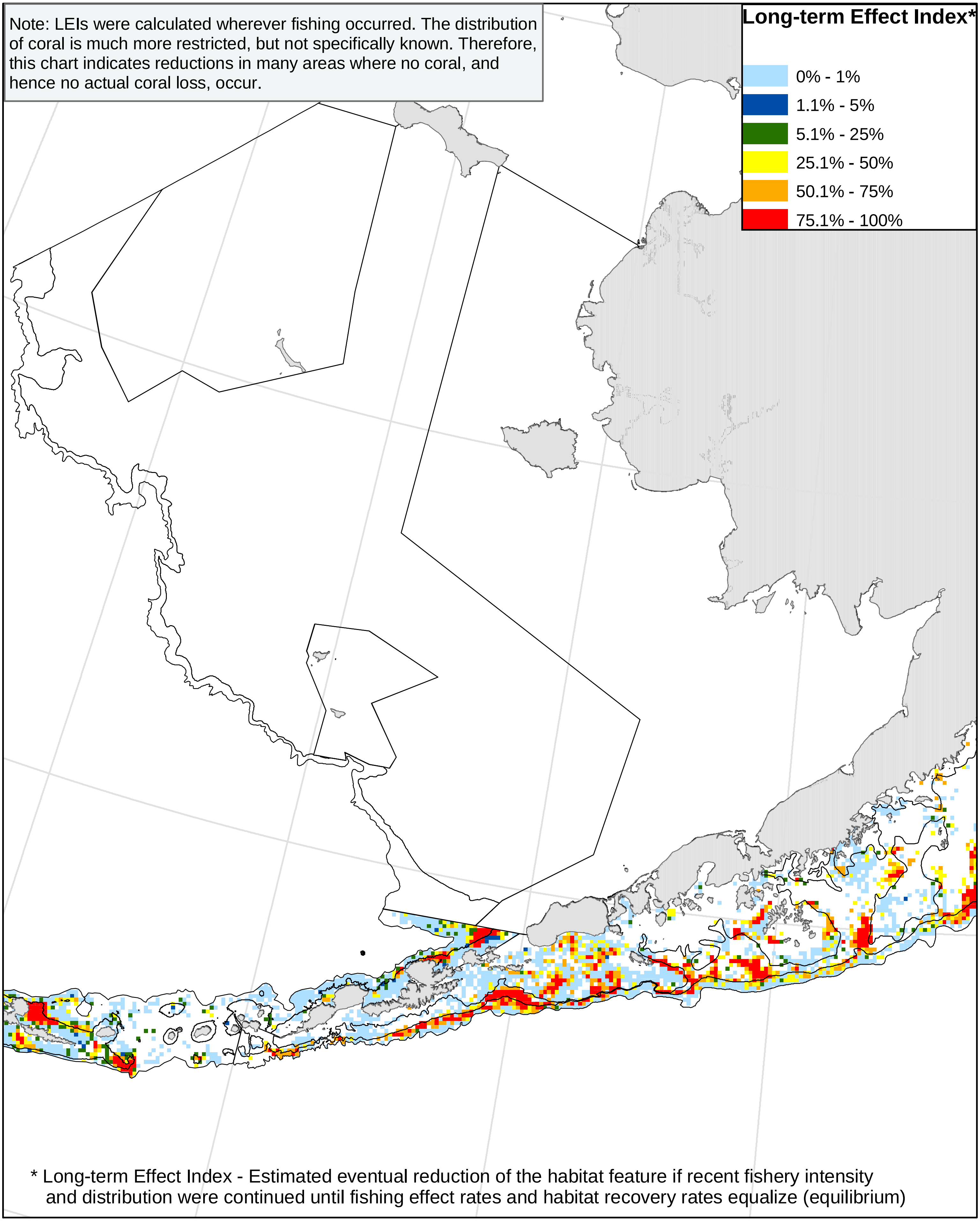


Fig B.2-6b. Distribution of Long-term Effect Index (LEI) of fishing effects on coral - Gulf of Alaska

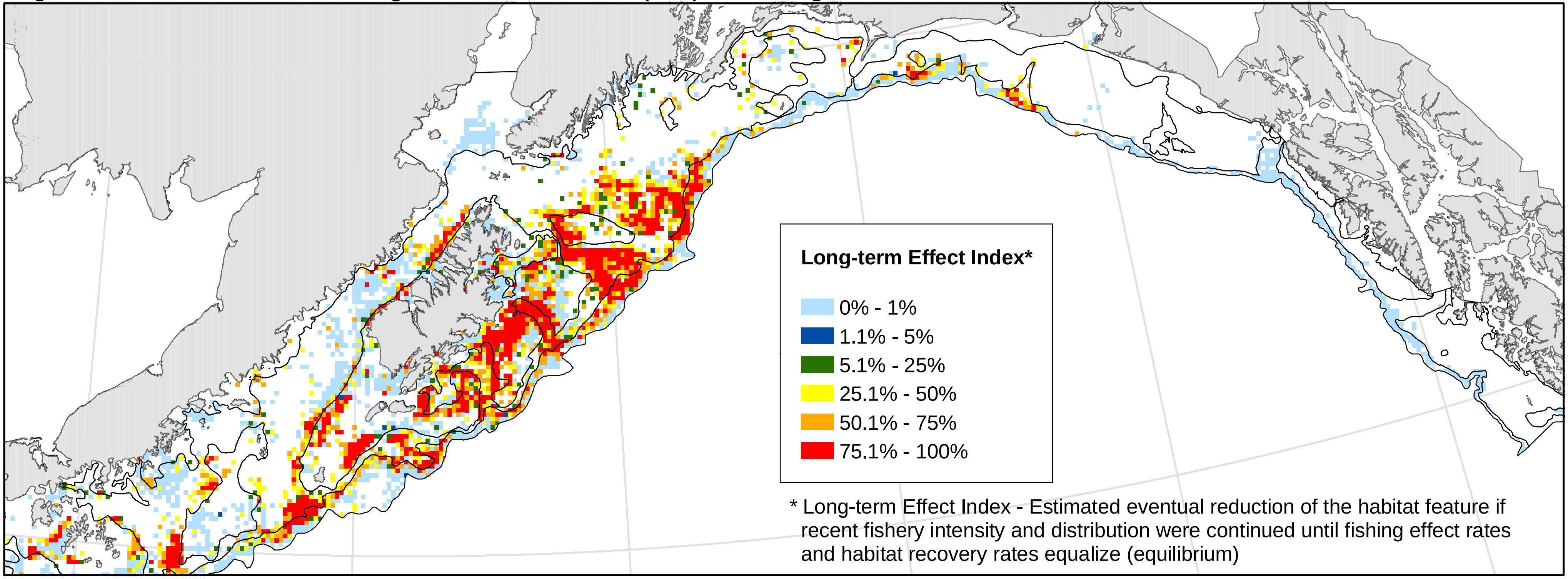


Fig B.2-6c. Distribution of Long-term Effect Index (LEI) of fishing effects on coral- Aleutian Islands